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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PROJECT: IS/ETH/73/009

Bulk Handling, Mixing and Bagging Plant for Fertilizers

Final Report
by

M. C. GEERLING
U.N.I.D.O. EXPERT

This report has not been cleared by UNIDO, which therefore does not necessarily share the views presented.

ADDIS ABABA, ETHIOPIA APRIL 1975

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— full names, addresses, functions etc

CHAPTER I

I - 1 Introduction

Apart from some large estates, the use of chemical fertilizers started in Ethiopia in 1967 and since its use has risen considerably. Ethiopia is largely an agrarian country; its crops are needed to feed the population and moreover the export of agricultural products is a major source of foreign currency.

The Government, through the Ministry of Agriculture and its organizations of which EPID (Extension and Project Implementation Department) is a very important one, stimulates the use of improved farming methods, including the use of fertilizers. Practically FAO officials run the EPID fertilizer distribution schemes and are responsible for demonstration plots and training. In Annex C-2 the names of the four FAO experts are mentioned. In 1971 under EPID supervision the "Minimum Package Programme" (MPP) came into operation. Other important development programmes are "Chilalo Agricultural Development Unit" (CADU) and "Wollamo Agricultural Development Unit" (WADU). These programmes aim to help farmers to arrive at improved methods, they arrange for marketing centres etc.

The success of these programmes was great and their extensions continue. It can be said that the response of Ethiopian farmers as experienced by EPID was very positive and beyond the original expectations. No doubt this will lead to a growing use of fertilizers.

I- 1.2 In 1972 a UNIDO team consisting of Mr. J.S. Garrer, Mr. M.E. Gertsch and Mr. K.A. Sherwin investigated the Ethiopia situation as to fertilizers. Gertsch made a Demand Projection study, Sherwin reported about Fertilizer Procurement Distribution and Garrer made a final report to which was added a study on the possibilities of establishing a fertilizer complex in Ethiopia. In the first phase a bulk handling and bagging plant was foreseen exclusively for bagging diammonium phosphate and urea. In the later phase the production within the country of DAP and of urea from phosphoric acid and ammonia is foreseen. Raw materials should be sulphur, rockphosphate and naphta.

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Neither in the Demand Projections nor in the production is foreseen in other fertilizers but DAP and urea. More specifically neither the use of mixed fertilizers nor the use of compounds was foreseen or recommended.

I- 1.3. However the experiences of EPID/FAO were different. It turned out that the use of mixed fertilizers and more specifically the use of grades 1:1:0, 1:1.5:0 and 1:2:0 should be recommended as these fertilizers enable farmers to apply the necessary amounts of nutrients in the easiest way. From 1974 on mixed fertilizers of grade 1:1:0 are imported. The use of mixed fertilizers is expected to grow and therefore the implementation of a mixing plant should be studied and a new Demand Projection has to be made.

I- 1.4. As a result a new project was formulated named "Bulk Handling, Mixing and Bagging Plant for Fertilizer, Project No. IS/ETH/73/009/Rev.1. The Terms of Reference to this project were agreed upon on 19 Sep.1974 after my arrival in Ethiopia in Sept. 1974; they are added as an annex to this report.

I- 1.5 It was recognized by Jarrer and his team that the fertilizer factory should be established near a harbour. Their arguments are invariably valid at present. Assab (one of the two Ethiopian harbours. Both are situated at the Red Sea coast; see map in Chapter IV) is the best choice as its situation to the Ethiopian interior is better than that of Massawa, the other Ethiopian port. When after some years production of phosphoric acid and its derivates is feasible the arguments to be in the immediate vicinity of harbour are even more valid. It was recongnized that all circumstances allow to start the implementation of the mixing and bagging plant without dealy.

I- 1.6 The best site to build the factory in Assab is at the coast at about 4 km south of the town of Assab, near the road to Addis Ababa and in the neighbourhood of an oil refinery. Unloading of raw materials is provided for at Assab-harbour and materials are to be transported to the factory by tipping trucks. In a later phase a jetty should be constructed allowing to convey materials into the factory without the use of trucks.

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I-1.7 The factory in its first phase should contain appropriate equipment and buildings to store raw materials and bagged fertilizers, a bulk blending mixing plant and a baggingplant.

I-1.8 Transportation to primary storages mainly should be done by trucks. A smaller part to be used in the norther part (Eritrea) should be shipped to Massawa by sea going vessel and further by truck or train.

It is important to realize a regular schedule of transportation; in that case a relative small storage of bags at the factory site is needed.

I-1.9 The Engineering and Economical Departments of the Agricultural and Industrial Development Bank (AID-Bank) helped in my activities. Discussions, reviews and participations added to the fullfilment of my task. I am greatly indebted to Ato Wondwossen Sahle, Ato Tadewos Harege Work, Dr. E.H.G. Gowen, Ato Lemma Merid and Ato Makonnen Abraham for their contributions and their interest. I feel grateful for the cooperation with EPID/FAO and I wish to thank Dr. K. Zschernitz, Mr. H.H. Scharling, Mr. H. Holmberg and Mr. A.V.E. Slangen with whom I had many most fruitful discussions and who gave valuable informations.

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1 US$ = 2,07 Eth$ (April '75)

I-2. **Summary**

I-2.1 Fertilizer use in Ethiopia has developed since 1967 at a rate of 49% per year. The use of fertilizers has been introduced to small farmers by EPID/FAO; their responsive was positive.

I-2.2 Based on data and informations of officials of EPID/FAO, Ministry of Agriculture and others a demand projection could be made. A growth rate of about 20% per year is considered by FAO as realistic. The results are that the consumption should rise from 65,000 tons (containing 22,700 tons of P_2O_5 and 15,400 tons of N) in 1974/75 to 424,000 tons of fertilizers (containing 132,000 tons of P_2O_5 and 1,134,000 tons of N) in 1983/84. Alternative growth rates of 15% and 25% are presented in Chapter III Tables 6 and 7. Plans to improve infrastructure, land tenancy conditions are drawn up and their implementation has started. The realization of these plans is of utmost importance to achieve the goals of the demand projections.

I-2.3 The demand projections justify the establishment of a fertilizer production complex. At the start a bulk blending unit and bagging facilities will satisfy the needs. About 1979 a sulphuric acid plant, a phosphoric acid plant and diammonium phosphate plant should be on stream. Raw materials are sulphur, phosphate rock and liquid ammonia. These products should be imported. These are indications of deposits of sulphur and phosphate rock in Ethiopia, but very little is known about.

Natural gas deposits are found at great distance from Assab. At present there is few information as to quality and quantities. It might be a raw material for ammonia production; in that case export of excess N-fertilizers is necessary. About 1981 the consumption of mixed fertilizers reaches a volume of 140,000 tons per year. It should then be considered to replace the bulk blending unit by a compounding plant.

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I- 2.4. In the early stages of production of mixed fertilizers and of bagging activities raw materials have to be unloaded at Assab-Harbour. Transportation to the factory-site at 4 km distance has to be done by tipping trucks. If volumes to be handled increase and this more urgently applies to the situation in which sulphur, phosphate rock etc have to be imported a jetty near the factory should be available. The jetty should be equipped with harbour crane(s) and a belt conveyor system, thus eliminating the use of trucks. The construction of this jetty is being studied. Its implementation should be realised in 1979. A storage for 15,000 ton of raw materials equipped with bucket elevator and beltconveyor is foreseen.

I- 2.5. The mixing plant should have a capacity of 40-50 tons/hr. Several plants of this capacity have been built in U.S.A. based on batch processing and are functioning at full satisfaction. The unit should contain a screen to remove lumps, a lumpbreaker; a batch weighing scale and a rotary batch mixer. Conveying equipment and hoppers complete the plant.

I- 2.6. Fillers should be used in mixing procedures. The Ministry of Mines investigates deposits of (coral) sands that might supply appropriate filler material. These investigations will be completed soon.

I- 2.7. Two bagging units are foreseen, each of 40-50 tons hourly capacity. As only bagged fertilizer are to be delivered the mixing unit should discharge directly into a bagging unit. The second bagging unit is to be used for the bagging of straight fertilizers. A storage for 1000 tons of bagged fertilizers is foreseen.

I-2.8 Auxiliary services and utilities should contain water supply, power station, workshop, fuel station for trucks, a truck weigher etc. An office building should contain as well laboratory, canteen, first aid room etc. Water and electricity mains are at short distance (several hundreds of meters) from the site.

I-2.9 Raw materials for mixed fertilizers are mainly DAP, urea, some TSP and a filler. Very small amounts of potassium fertilizer are projected.

I-2.10 Bags preferably should be a woven bag with an inner made out of p.e. This type of bag has proved to be able to stand the service conditions of transportation to the final consumer. If the infrastructure is improved it should be investigated to use a thick p.e. bag without woven outer bags. At present woven bags and p.e. bags are produced in the country.

I-2.11 The transportation of bagged fertilizers from the factory in Assab, into the country for the greater part has to be done by trucks. Part of the fertilizers destined for the northern part of the country can be transported by coaster-ships and subsequently by train and by truck.

It is essential that truck transport is easily and permanently available to avoid accumulations of stocks of bagged fertilizers at the factory.

I-2.12 Personnel is easily available and much of the equipment could be operated normally, thus avoiding expensive and sensitive automatic equipment. Foremen, laboratory techniciansand some of the operators have to be properly trained. The manager should have experience in processing industries and specific training in a mixing and bagging plant.

I-2.13 Investment costs of the complete mixing and bagging plant including bulk handling facilities, storage for bagged fertilizers utilities and auxiliaries is estimated at $5,200,000.

I-2.14 The operating costs of the bulk handling activities inlcuding unloading of ships and transportation to the factory is calculated to be $2.18 and $1.62/ton respectively for yearly volumes of 100,000 tons and 200,000 tons. The operating costs of the handling of raw materials and of bagged fertilizers plus the cost of mixing and bagging operations are $10.18 and $5.85 per ton respectively for volumes of 100,000 and 200,000 tons per year.

I-2.15 Based on quantities to be handled in 1976/77 a calculation was made about cost of import of bagged fertilizers as processing in Assab. A difference of 9.35 million results in favour of processing in Assab.

I-2.16 Working capital requirements were calculated to be for:-

1976/77	$9278,000	1979/80	$9,400,800
1977/78	$9,003,600	1980/81	$9,617,400
1978/79	$9,211,300		

I- 3. Conclusions and Recommendations

I- 3.1. A bulk handling mixing and bagging plant should be built in Assab without delay.

I- 3.2. For unloading activities at Assab-Harbour grabs to be used with the ship's gear and appropriate hoppers should be purchased. A fleet of 8 tipping trucks to be loaded at the hoppers is needed for transportation to the factory storage. This storage should have a capacity of 15,000 tons.

I- 3.3. When purchasing raw materials care should be taken as to specifications. Important for mixing activities is granule size and all materials to be mixed, including fillers should have the same granule size. It is strongly recommended to contact the "International Fertilizer Supply Scheme" of FAO at Rome when purchasing fertilizers.

I- 3.4. Filler materials can be found near Assab. A report of the Ministry of Mines dealing with this subject can be envisaged within a few weeks. By then decisions about equipment can be made.

I- 3.5. The mixing plant should be fed by wheelloaders. The plant should be at short distance from the raw material storage. Mixing capacity should be 40-50 ton/hour.

I- 3.6. The bagging plant should contain two identical units of 40-50 ton enabling to bag different fertilizers simultaneously. The production of the mixing unit should discharge into one of the bagging units thus avoiding intermediate storage of mixes.

I- 3.7. Woven bags with inner p.e. liners should be used. Both can be produced in Ethiopia. In due time a study should be made to use other and cheaper types of bags. Outer bags should be printed to indicate the type and grade of the fertilizer.

I- 3.8. Bagged fertilizers should be transported without delay to their final destinations. A system of primary, secondary etc storages should be developed and extended. Close cooperation with organisations concerned are necessary. For transportation of 100,000 - 150,000 ton of fertilizer a fleet of over 80 trucks is needed, assuming a regular pattern of transportation is realized. It should be studied whether transportation should be done by a company owned truck fleet or in close cooperation with a transport company. Deviations from a regular transportation schedule lead to the construction of large and costly storages for bagged fertilizers and the necessity to use a large number of trucks at irregular intervals.

I- 3.9. Utmost attention should be given to maintenance. Maintenance schedules aiming at preventive ~~maintenance~~ should be made in cooperation with the construction engineer. It should be emphasized that preventive maintenance is by far cheaper, both as to the extent of repairs as well as to losses of production. Break-down maintenance can be prevented considerably by using schedules for preventive maintenance.

I- 3.10. A study was made on the possibility of the implementation of a pesticide formulation plant by UNIDO-expert Mr. Andreasen. He recommended to build this plant at Assab. Sugestions were made to incorporate this plant into the fertilizers plant. Marketing and distribution problems for pesticides and fertilizers are very much the same. Therefore a joint management and sharing of activities as laboratory, maintenance utilities, accounting etc might be profitable. It is recommended to study the possibilities of such a combination.

CHAPTER II

Past trends of fertilizer use

II-1. An extensive Fertilizer Programme aimed at the introduction of fertilizers to small and commercial farmers started in 1967. Earlier some large estates imported fertilizers but the amounts were limited. In 1966 imports totalled 1203 ton.

From 1967 on fertilizers trials were carried out and gradually fertilizers were introduced to small farmers. The Ministry of Agriculture established the "Institute of Agricultural Research" and the "Extension and Project Implementation Department (EPID). The research Institute carries out several tasks, among them investigation on fertilizers. EPID started in 1971 and incorporated the F.A.O. Fertilizer Programme, Under EPID supervision the Minimum Package Programme (MPP) came into operation. Other important development programmes are the "Chilalo Agricultural Development Unit" (CADU) and the Wollamo Agricultural Development Unit (WADU)(see F.A.O. report TF-ETH-13-DEN. by D.L. Rucker, Rome 1974, AS/F4345).

These programme deal with small farmers and proved to be very successful. The response of the farmers to new agricultural techniques was very positive and beyond expectation.

II-2. Import of fertilizers

In the "Annual External Trade Statistics" 1967-73 (issued by the Cus toms Head Office, Addis Ababa) fertilizers are listed under four headings:-

(i) Nitrogeneous fertilizers & fertilizer materials
(ii) Phosphatic fertilizers & fertilizer materials
(iii) Potassic fertilizers & fertilizer materials
(iv) Fertilizers manufactured n.e.s.

Apparently (i) refers to urea and sulphate of ammonia, (ii) to triple superphosphate, (iii) to muriate of potassium and (iv) to diammonium phosphate and compounds. The total volumes are the more important data. From these latter data it can be seen (table 1) that there was a rapid increase in fertilizer imports. It must be kept in mind that the quantities mentioned are the imported quantities; the consumption patterns are different because of carry-overs.

Table II-1

Imports of Fertilizer into Ethiopia
(Volume in tons; Value in E$)

Year	Nitrogenous Fertilizers & Materials (UREA)		Phosphatic Fertilizer & Fertilizer Materials (TSP)		Potassic Fertilizer & Fertilizer Materials (NPK)		Fertilizers Manufactured n.e.s. (DAP)		TOTAL	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1967	3,389	663,906	9	12,760	719	175,625	348	85,243	4,465	937,534
1968	1,994	587,497	277	66,337	20	4,320	906	325,501	3,197	987,653
1969	558	168,859	1,129	259,590	320	63,174	6,193	1,172,368	8,200	1,663,991
1970	593	159,420	3,582	722,876	50	10,080	5,928	1,326,691	10,153	2,219,067
1971	2,331	428,875	5,534	900,612	51	13,420	14,711	3,505,673	22,627	5,848,380
1972	3,141	678,065	396	91,609	100	41,750	13,737	3,271,570	17,369	4,077,994
1973	2,881	607,690	3,377	731,606	-	-	41,810	11,624,802	48,068	12,964,098

SOURCE: CUSTOMS HEAD OFFICE: ANNUAL EXTERNAL TRADE STATISTICS, 1967 - 1973

The rise from 4465 tons in 1967 to 48,068 tons in 1973 represents an average annual growth of 49% assuming that there were no carryovers of the 48,068 imported in 1973. This very high annual growth is only possible at the very start of fertil[illegible] introduction and for the years to come growth rates will be much lower. The high rates at the start however do indicate that Ethiopian agriculture responded in a positive way to the use of fertilizers.

The table shows that the 4th group of fertilizers (DAP) has the largest volume, second is the 1st group (nitrogeneous fertilizers). The group of phosphatic fertilizers (TSP) declined, whereas potassium never reached a high volume. This is in agreement with the fact that Ethiopian soils are not deficient as regard to potassium. Moreover TSP (42-46%) as single nutrient fertilizer is replaced by DAP (18-46) fertilizer with about the same content of phosphorus at the same time containing nitrogen.

II-3. Consumption patterns

As to the consumption of fertilizer a paper read by Ato Mammo Bahta at the U.N's Second Interregional Fertilizers Symposium at Kiev/New Delhi 1971 gives details about the years 1967-1970. This paper contains detailed information about consumption and the data presented cover all agricultural activities in the country including small farmers, commercial farmers and estates.

Table 2 gives a compilation of these consumption data.

Table 2

	1967	1968	1969	1970	Total
Straight N-fertilizers	1,263 ton	517	5,022	4,720	11,522
Straight P-Fertilizers	63	118	673	533	1,387
Straight K-fertilizers	54	48	167	106	375
NP-fertilizers	163	378	996	3,315	4,852
NK-fertilizers	47	-	32	39	118
NPK-fertilizers	1,301	1,006	924	2,062	5,293
T o t a l	2,891	2,067	7,814	10,775	23,547

Comparing this table with the data from table 1 there is a reasonable agreement as to the <u>total</u> volumes.

Imports in 1967/70 were 26,015 tons; whereas consumption was 23,547 t. The difference can be explained by a carry-over of 2,468 tons which is in every was a reasonable amount.

In table 3 import and consumption data covering the years 1967-1970 are presented.

Table 3

	Import	Consumption
N-Fertilizers	6,534 ton	11,522
P-Fertilizers	4,997 ton	1,387
K-Fertilizers	1,109 ton	375
Compounds and others	13,375 ton	10,263
T o t a l	26,015 ton	23,547

Comparing the import data with the consumption data there are contradictions. N-consumption is considerably higher (75%) than is the import. This must be due to a mistake. Most probably some types of fertilizers are listed wrongly in the import statistics. As the names of many fertilizers types are rather complicated and trade names often are confusing this is readily understandable.

As to P-Fertilizers, probably DAP is sometimes considered as a phosphatic fertilizer sometimes as a compound. The consumption data covering the years 1971 and after are not available. Only for some groups of agricultural activities data can be produced, but a comprehensive picture cannot be formed. For these years only the import statistics contain reliable data.

II-4. The Kiev/New Delhi paper mentioned before gives some very valuable information as to the types of fertilizers.
N-Fertilizers. There is a significant change in the types of N-Fertilizers. In the beginning the majority of the N-Fertilizers were nitrates, whereas in 1970 the nitrates only present a very small amount and urea and sulphate of ammonia are the important N-Fertilizers.

Table 4.

	1967	1968	1969	1970
Nitrates	1,035	40	674	112
SA + Urea	228	477	4,348	4,608

The reason for this reversal evidently is the hygroscopic nature of nitrate fertilizers. Urea and SA have relative humidities (rh) of 75.2 and 79.2% respectively, nitrates show (rh's of 59.4-62.3% (see Chapter VII). As a consequence nitrates readily attract water and become sticky and humid. In this respect Urea and SA are far better to handle and do not cause problems in Ethiopia. Another reason may be that during rainy seasons nitrates dissolve in the water and seep in the soil beyond the reach of the plants roots, whereas urea and the ammonium of SA are adsorbed at the soil particles.

Moreover in hot climates nitrates have no advantages over other N-Fertilizers as they have in cold climates.

Potassium Fertilizers

Rather important amounts of potassium fertilizers were used (see table 2), mainly as NPK-Fertilizers. During the years 1967 upto 1970 there is first a decline, but in 1970 a substantial rise is reported in the form of NPK Fertilizers. Apparently extensive research was carried out on potassium fertilizers but with little or no response of crops to potassium. Gertsch reports (July 1972) that it was shown that potassium was practically of no use in Ethiopia. EPID has the same experiences. At present only small amounts (100-200t) are imported, apparently to be used for tobacco culture. For the future very little amounts of potassium are foreseen.

CHAPTER III

Demand Projections

General

Fertilizer use started in Ethiopia about 1967. From 1967 on statistical data on import of fertilizers are reported in the "Annual External Trade Statistics" as issued by the Customs Head Office in Addis Ababa. In table 9 these data are presented upto 1972. The data for 1973 and 1974 are not available presently. The quantities mentioned are the imported quantities; the consumption patterns are different because of carry-overs. Data on consumption are not available. However the rise from 4,500 ton in 1967 to 48,000 ton in 1973 represents an average annual growth of 48%.

In the study on "Fertilizer Manufacture in Ethiopia" made by a UNIDO-Team, composed of Mr. J.S. Carrer, Mr. M.E. Gertsch and Mr. R.S. Sherwin, in 1972 (Report ETH-054/-A/SLS) a demand projection is presented made by Mr. Gertsch.

These projections were chequed. It can be said that actually fertilizer consumptions were higher than those projected by Gertsch. The actual demands for the season of 1974/75 now are 65,800 ton, as compared to Gertsch's projection of 52,900 tons.

But not only the total amounts of fertilizer are different, even more important is the fact that the urea consumption turned out to be much lower than projected by Gertsch, whereas the phosphate consumption was much higher. It was therefore necessary to consider once again the consumptions of different types of crops, its growth rates and the growth of area under cultivation. On the whole the projection was developed through frequent discussions with officials from FAO and other experts from various Governments bodies associated with agricultural enterprices, including AID Bank.

2. [illegible]

2.1. The practical results of the last years as to the use of fertilizers in Ethiopia were beyond expectation. More specifically the response of small farmers as experienced by the "Extension and Project Implementation Department" (EPID) of the Ministry of Agriculture, was very significant. EPID started in 1971 and incorporated the F.A.O. Fertilizer Programme. Under EPID supervision the "Minimum Package Programme"(MPP) came into operation. Other important development projects are the "Chilalo Agricultural Development Unit" (CADU) and the Wollamo Agricultural Development Unit" (WADU). Details about these programmes are laid down in a F.A.O. report (TF-ETH 13-DEN) by D.L. Becker, Rome. 974, WS/F4345. This report deals with Marketing and Credit Problems for Fertilizers in Ethiopia.

The programmes mentioned deal with small farmers and as said before its implementation proved to be more successful than was expected. As a matter of fact in four years 48 MPP's were implemented whereas only 40 were foreseen. In the next years to come the implementation of 10 MPP's per year are planned. This is far more than was taken into consideration by Gertsch, who was rather pessimistic about the results of the introduction of MPP's.

2.2. It can now be stated that the response of the small farmers to better agricultural techniques, including the use of fertilizers was beyond expectations. As they have accepted the use of fertilizers as an important contribution to more and better crops, the future growth of fertilizer consumption shall mainly depend on other factors.

Some of the important factors are:-

(a) Fertilizer prices, including subsidies from the government. It can be mentioned that such subsidies are realised

(b) Prices of Crops, and its stablisations. As a result of (a) and (b), the cost/benefit ratio has to be at least 2 in order to raise the interest of the farmers.

(c) Implementation of plans as to infrastructure, including construction of roads, warehouses etc.

(d) Land reform augmenting the small farmer's profits in the crops he raised.

More specifically the present high fertilizer prices can be a draw-back to the use of more fertilizers. It could be compensated to a certain extent by subsidies and by higher crop prices. Land reform could be a positive factor, as is a good infrastructure. All in all there are many uncertain factors as to the future use of fertilizers.

3. Growth patterns

3.1. After discussions with the officials mentioned earlier, it was agreed that a yearly growth of fertilizer use of 20% on the areas presently under cultivation by small farmers producing grains, fruits vegetables, pulses, oilseeds and peppers is a realistic starting point.

3.2. Every year new land is taken into agricultural use and added to the area under cultivation by small farmers to be used for the same types of crops. Statistical data are available as to the growth of cultivated area for different crops for the years 1967/68 upto 1971/72.

In table 1 these data are presented with the growth rates. The arithmetic average in growth is used in further calculations for the area to be fertilized in the future. As apparently sweet potatoes, ensette, sisal, chat and gesho are not fertilized they are not included in further demand calculations. Table 2 presents the area to be used for different crops for the years from 1973 on. Comparison of the areas and the amounts of fertilizer to be used in the years to come show that even in 1984 not all crops use the amounts of fertilizer needed for optimum yields.

3.3. Basis for the demand projections are the present uses. The total amount of fertilizer to be used by small farmers (M.P.P, WADU, CADU and others) is estimated to be 42,000 tons for the season of 1974/75. EPID knows from experience that the average distribution of fertilizers among different kinds of crops raised by this group of farmers is: Teff 40%, wheat 12%, Barley 8%, Maize 9%, Sorghum 6%, Dagussa 5%, Pulses 8%, Oilseeds 8%, Fruit and Vegetables 2%, Peppers 2%.

3.4. Moreover there are direct imports for crops raised by commercial farmers and estates. Their estimates for 1974/75 season follows:-

Oilseeds 6000 ton, various crops 6000 ton, Cotton 7000 ton, Sugarcane 3900 ton, Tobacco 50 ton, other NPK using crops 150 ton. Total 23,100 tons.

4. Types of Fertilizer

4.1. In the group of crops raised by small farmers up to now the most used fertilizers have been DAP (which represents a nutrient ratio of 1:2.6:0) and to a lesser extent urea. For the year 1974/75 this pattern of application is foreseen. However for many of these crops a ratio 1:2:0 is foreseen by the beginning of the year 1975/76 and to be raised to 1:1:0 beginning in 1979. (see table 3).

Gertsch had foreseen that only DAP and urea should be used on these crops, preferably with urea as top-dressing. It was shown that small farmers considered this as a too complicated procedure and that one single application was a more easy practice. Therefore, mixed fertilizers with a higher nitrogen content are foreseen for the years to come and these products (mainly 1:2:0 and 1:1:0) should be produced in the bulk blending plant by mixing DAP and urea. Therefore these two products are to be imported in large quantities. In our calculations the amounts of fertilizers to be used are therefore expressed in terms of D.A.P. and urea. (see table 3) as well as in terms of nutrients (see table 4). This means that the relative amount of urea as compared with DAP will raise in the years to come but not as high as foreseen in Gertsch's projections. (In the tables seasons are indicated e.g 1974/75; it must be stated that <u>the use of fertilizer</u> for the greater part is in 1975. Import and production however start in 1974).

4.2. As to the crops mentioned before the amounts and the types of fertilizers foreseen to be used in the demand projections from 1975/76 on were fixed at:-

<u>Teff</u>: ratio 1:2:0 (or per HA: 1qt DAP + 0.[illegible]1 qt urea)
From 1979 on: ratio 1:1.5:0(or per HA.1qt DAP + 0.27 qt urea) For Teff overall growth rate is 21%

<u>Barley</u>: as Teff. Overall growth rate 21%

<u>Sorghum</u>: as Teff. Overall growth rate 21%

<u>Wheat</u>: ratio 1:1:0 (or per HA: 1qt DAP + 0.61 qt urea)
Overall growth rate 22%

<u>Maize</u>: ratio 1:2:0 (or per HA: 1.5 qt DAP + 0.91 qt urea).
Overall growth rate 22%

<u>Dagussa</u>: ratio 1:2.6:0(or per HA: 1qt DAP.) Overall growth rate 21%

<u>Other food crops</u>: ratio 1:2:0(or per HA: 1qt DAP + 0.11 qt urea) Overall growth rate 20%

Pulses: ratio 1:2,6:0 (per HA: 1qt DAP). Overall growth rate is 22%

Oilseeds: ratio 1:1,1:0 (per HA: 1qt of DAP + 0.5 qt of urea). Overall growth rate is 24%

Fruit and Vegetables: ratio 1,4:1:0 (per HA: 1qt DAP + 1qt urea) Overall growth rate is 23%

Pepper: ratio: 1:1:0 (per HA: 1.5 qt DAP + 0.5 qt urea) Overall growth rate is 22%

4.3. Apart from these crops there are a number of crops like cotton, sugarcane, tobacco and coffee that are cultivated in larger estates. We were able to get information from the growers of these products on the size of cultivation and level of fertilizer consumption.

Coffee: The F.A.O. Coffee Survey Service informed us that at present only 50 tons of fertilizers are used for coffee. Coffee mainly is picked in forests and less than 30% is from cultivated area.

Research on the results of fertilizer use on coffee is underway. But upto now results are not very promising and nothing can be said as to the final outcome. For the time being coffee cannot be considered as a potential fertilizer consumer.

Cotton: The Awash Valley Authority, under whose care most of the cotton in Ethiopia is raised, informed us about the situation as to this crop in Ethiopia. Actually 66,700 HA are under cotton, of which 45,700 HA are fertilized. An average of 1.5 qt of urea per HA is applied. No phosphatic fertilizers are used. The fertilized area (45,700 HA) are increased by 7% per year (see Bottomly. SLB 71/142/Eth 72). Moreover new cotton areas are to be developed in Ilubabor and South of Arba Minch. These areas will grow up to 10,000 HA each, from now until 1982.

In 7 years the area grew from 45,700 HA to 65,700 HA, this represents a growth of 43.7% in 7 years or 5.3% per year. Both growth percentages result in an average yearly growth of 13%. Moreover it is assumed that there is a yearly increase in the use of fertilizer per HA of about 6%. In our projections a total growth of 20% per year is assumed.

Sugarcane H.V.A. informed us about fertilizer use in the sugarcane estates. Sugarcane and its processing to sugar is limited to large estates. Only nitrogen fertilizers are used. The estates presently under cultivation are not to be extended as the capacity of the factories does not allow such extensions. However, a new factory is projected to be on stream in 1979; its final production will be reached in about 10 years.

Presently fertilizer use is 1300 ton of urea and 2,600 tons of sulphate of ammonia and these quantities remain constant. The new estate will use fertilizer from 1978 on and its use will be 260 tons of urea in the first year. Growth will be 260 tons per year for 7 or 8 years.

Tobacco. The Ethiopian Tobacco Board informed us about the present and the future use of fertilizer. Only NPK 15:15:15 is used. Total amounts are rather low and will raise from 50 tons in 1974/75, gradually to 290 tons in 1980/81 and then remain at that level.

Pastures Gertsch assumed a considerable fertilizer use on pastures and projects a use of 35,000 tons of urea in 1984. Presently no urea is used on pastures and no plans to do so exist. Experiments in Kenya showed a higher grass production that however did not result in any economic benefit. Better breeds with higher milk and meat production might give another picture. For the years to come therefore a use of fertilizers on pasture is unlikely to exist. So we have not foreseen such a consumption.

4.4. The use of potassium at present is very low and for the near future no potassium consumption of any importance can be foreseen. It is possible that in the future a larger need for this nutrient will develop. Part of potassium imported is for tobacco crops, however, import data allow to presume some additional use of this nutrient (see table 9). So therefore in the demand projection (table 3) a limited amount of these fertilizers for crops other than tobacco is foreseen. Groundnuts may be one of these crops.

5. Projections

5.1. Table 3 shows the results of the calculations based on the assumptions mentioned before in terms of fertilizer products. Table 4 shows these resulsts in terms of nutrients.

5.2. Part of the fertilizers are to be used as mixed fertilizers, whereas another part shall be used as straight fertilizers. A calculation is made on the amount of fertilizers that as a maximum could be used in the form of mixed fertilizers. Table 5 presents these amounts. It must however be kept in mind that in some cases, the use of straight fertilizers might be preferred. An estimate of the percentage of the above mentioned maximum is made. Accordingly the probable minimum amounts of fertilizers to be used as mixed fertilizer are calculated. At high volumes of mixed fertilizers, the production of compounds fertilizers has to be considered.

5.3. Sensivity tests at 15% and 25% growth rates as to fertilizer use were made. In these calculations the growth rates of the area under cultivation are taken into consideration in the same way as mentioned for the growth rate of 20%.

Table 6 shows the results for a rate based on 15%, table 7 for a rate based on 25% growth. In Table 8 a comparison of these three alternatives is presented.
The data in Table 3 however are to be considered as the most reliable that can be produced at present.

5.4. An attempt to calculate the amount of fertilizers enabling to produce enough cereals to feed the Ethiopian population was made. Basis for the calculations are statistical data as to area cultivated by cereals, yield per HA, losses due to pests etc, needs for sowing seed, amount of cereals needed per capita and population and its growth.

Statistical data were obtained from: "The Demography of Ethiopia", vol 1, Centr. Statistic Office, Jan.1974, Staff report No.3 Centr. Statistic Office, October 1972 and from informations received from several officials. Many statistical data are estimates rather than based on extensive investigations. Therefore the results of the calculations have to be accepted with some reserve. Calculations were made for three years 1975, 1980 and 1985.

Yield per Ha. for the major cereals crops is 730 kg per HA (Statistic Abstracts 1971). This figure is related to no use of fertilizers. It is assumed that 100 kg fertilizer gives an average extra yield of 400 kg cereals per HA.

The needs per capita are not well known. Data varying between 190 and 150 kg are mentioned. As part of the cereals is used for the production of Tella, Beer etc. 190 kg must be considered at realistic.

Average losses due to rodents, insects, decay etc. including needs for sowing seeds are calculated to be 23%. Therefore 247 kg has to be produced in order to supply 190 kg per capita.

Calculations have been made to establish what the yield per HA must be in order to arrive at the consumption of 190 kg p.c.

The calculated yield per HA is compared with the average of 740 kg/HA and the surplus to be produced in relation to fertilizers. For better agricultural methods and new varieties also can enlarge the yield per HA. On the other hand high yield varieties asks for large amounts of fertilizers. All in all there are a large number of factors that may influence the results. Therefore the results are of limited value and must be considered as an indication that the demand projections do not exceed potential demands. If development of infrastructure and training of farmers to use fertilizers can be accelerated fertilizer production should be enlarged accordingly. The results of the calculations that are presented in the table 1 indicate that to ensure a per capita consumption of cereals of 190 kg per year large amounts of fertilizers are needed.

The results of these calculations are rather sensitive to the level of per capita consumption. In table 2 a consumption level of 170 kg p.c. (220 kg production) is foreseen. The need for fertilizers in that case is much lower.

Table 11

Year	Population x million	Production wanted for 190 kg p.c x 1000 ton	Area for cereals x 1000 HA	Production needed kg/HA	Deficiency to 730 kg/HA	kg/HA fertilizer to compensate	Total amount of fertilizer	foreseen for cereals tons	%
1975 1980 1985	27.0 30.7 35.1	6,669 7,583 8,670	7,743 8,356 8,911	860 907 973	130 177 243	33 44 61	255,500 367,700 543,600	33,610 115,160 314,000	[illegible] [illegible] [illegible]

Table 12

Year	Population x million	Production wanted for 170 kgp.c x 1000 ton	Area for cereals x 1000 HA	Production needed kg/HA	Deficiency to 730 kg/HA	kg/HA fertilizer to compensate	Total amount of fertilizer	foreseen for cereals tons	%
1975 1980 1985	27.0 30.7 35.1	5,940 6,754 7,72[illegible]	7,743 8,356 8,911	767 808 866	37 78 136	9 20 34	69,690 167,710 302,000	33,610 115,160 314,000	48 [illegible] 104

Other food crops (beans, vegetables) and crops like oil seeds, etc are not considered in the foregoing calculations as nothing is known about consumption patterns.

It is reported that at present part of the population (some 2 million people) lives on milk and roots alone. It is not quite clear whether this group is included in the calculations mentioned in Staff Report No.3.

In case this group is not included the population data in table 1 have to be corrected. Assuming that further social development will shift consumption patterns to the use cereals it is probable that this group will diminish to 1.5 million in 1980 and to 1 million in 1985

Applying the basic data of table 11 (190 kg cereals per capita; area under cultivation) the amounts of fertilizers needed for cereals are calculated to be:-

in 1975 131,600 ton (33,610 t)
in 1980 275,700 ton (115,160 t)
in 1985 481,100 ton (314,000 t)

(figures between brackets are quantities projected for cereals) Even assuming that part of the population at present does not consume cereals the demand projections for fertilizers do not exceed potential needs.

Applying the basic data of table 12 (170 kg cereals per capita) fertilizer needs for cereals are calculated to be:-

in 1975	nil	(33,600 t)
in 1980	64,300 t	(115,160 t)
in 1985	249,500 t	(314,100 t)

This means that at present (1975) no fertilizers are needed for cereals. This contradicts the practice in which fertilizers are used and needed for cereals.
It can be concluded that this way of approach is not very reliable. This is due to the fact that the preliminary assumptions as yeield per Ha consumption per capita, population size etc. are not known accurately.

Moreover this type of calculation in which data have to be substracted is very sensitive to relative small differences in basic assumptions.

The only safe conclusion that can be made is that the projected volumes of production do not exceed the needs.

TABLE 1

GROWTH RATE OF AREAS UNDER DIFFERENT CROPS

(1000 ha)

	1967	%	1968	%	1969	%	1970	%	1971	%	Average growth rate
Teff	2,154.0	1.00	2,175.5	1.00	2,197.3	0.93	2,217.8	0.98	2,239.5	0.98	0.98
Wheat	1,028.6	2.00	1,049.2	2.00	1,070.2	2.00	1,091.6	2.00	1,113.4	2.00	2.00
Barley	1,693.2	1.22	1,713.9	1.22	1,734.8	1.22	1,756.0	1.10	1,775.4	1.19	1.19
Maize	828.4	1.12	837.7	1.12	847.1	1.95	865.6	1.14	882.1	1.58	1.58
Sorghum	1,174.0	1.07	1,186.6	[illegible]	1,203.2	1.28	1,218.0	[illegible]	1,233.5	1.24	1.24
Other (Dagusse)	299.3	0.50	300.8	0.50	302.3	0.50	303.8	0.50	305.3	0.50	0.50
Pulses	824.7	1.72	838.9	1.51	851.6	1.73	862.9	1.14	872.7	1.42	1.42
Oilseeds	746.8	3.39	772.1	3.72	800.8	3.51	828.9	3.10	854.6	3.43	3.42
Fruits & Vegetable (Including Potatoes)	131.0	(2.21)	128.1	6.71	136.7	2.05	139.5	1.94	142.2	2.12	2.12
Sweet Potatoes	57.4	1.57	58.3	1.54	59.2	0.90	60.1	1.50	61.0	1.38	-
[illegible]	233.2	1.42	236.5	1.44	239.9	1.38	243.2	1.36	246.5	1.40	1.40
Cotton	125.6	13.38	142.4	16.71	166.2	16.13	193.0	16.06	[illegible]	15.57	15.6
Sugarcane	5.9	-	5.9	27.12	7.5	16.00	8.7	3.45	9.0	11.64	14.6
Ensette	381.6	2.04	389.4	1.95	397.0	2.02	405.0	1.98	413.0	2.00	4.90
Coffee	611.5	0.57	615.0	0.57	618.5	0.57	622.0	0.64	626.0	0.59	0.47
[illegible]	3.4	8.82	3.7	8.11	4.0	7.5	4.3	6.98	4.6	7.85	7.85
Chat & Gesho	96.1	0.94	97.0	0.93	97.9	1.02	98.9	1.01	99.9	0.97	0.97
Tobacco	3.2	6.25	3.4	8.82	3.7	5.41	3.9	7.69	4.2	7.04	7.04

TABLE 2

PROJECTED AREA UNDER CULTIVATION

(1000 ha)

	Aver.growth rate for the years 1967/68 to 1971/72 %	Unit	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Teff	0.98	1000 ha	2,239.5	2,261.4	2,283.6	2,306.0	2,328.6	2,351.4	2,374.4	2,397.7	2,421.2	2,444.9	2,468.9
Wheat	2.00	"	1,113.4	1,135.7	1,158.4	1,181.5	1,205.2	1,229.3	1,253.9	1,278.9	1,304.5	1,330.6	1,357.2
Barley	1.19	"	1,775.4	1,796.5	1,817.9	1,839.5	1,861.4	1,883.6	1,906.0	1,928.7	1,951.6	1,974.8	1,998.3
Maize	1.58	"	882.1	896.0	910.2	924.6	939.2	954.0	969.1	984.4	1,000.0	1,015.8	1,031.8
Sorghum	1.24	"	1,233.5	1,248.8	1,264.3	1,280.0	1,295.8	1,311.9	1,328.1	1,344.6	1,361.2	1,378.1	1,395.2
Dagussa	0.50	"	305.3	306.8	308.4	309.9	311.5	313.0	314.6	316.2	317.8	319.4	321.0
Pulses	1.42	"	872.7	885.1	897.7	910.4	923.3	936.4	949.7	963.2	976.9	990.8	1,004.8
Oilseeds	3.43	"	854.6	883.9	914.2	945.6	978.0	1,011.6	1,046.3	1,082.2	1,119.3	1,157.7	1,197.4
Fruits & vegetable including potatoes	2.12	"	142.2	145.2	148.3	151.4	154.6	157.9	161.2	164.7	168.2	171.7	175.3
Pepper	1.40	"	246.5	250.0	253.4	257.0	260.6	264.2	267.9	271.6	275.4	279.3	283.2
Cotton		"	224.0	258.9	299.2	345.8	399.5	461.8	533.8	616.9	712.9	823.9	952.2
Sugarcane	-	ha.	-	8,355	8,951	9,155	9,556	9,791	9,711	9,735	9,735	9,735	9,735
Tobacco	-	"	-	1,450	1,450	1,450	1,450	1,450	1,450	1,450	1,450	1,450	1,450

PROJECTIONS BASED ON A [illegible] GROWTH RATE PL[illegible]

	Growth rate	Fertilizer in qt/HA			Requirements in tons 1974/75			Fertilizer in qt/HA			197[illegible]
		DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP
Teff	1.21	1.0	-	-	16,800	-	-	1.0	0.11	-	20,300
Wheat	1.22	1.0	-	-	5,040	-	-	1.0	0.61	-	6,150
Barley	1.21	1.0	-	-	3,360	-	-	1.0	0.11	-	4,070
Maize	1.22	1.5	0.5	-	2,840	950	-	1.5	0.91	-	3,460
Sorghum	1.21	1.0	-	-	2,520	-	-	1.0	0.11	-	3,050
Dagussa	1.21	1.0	-	-	2,100	-	-	1.0	-	-	2,540
Pulses	1.22	1.0	-	-	3,360	-	-	1.0	-	-	4,100
Oilseeds	1.24	1.0	0.5	-	6,240	3,120	-	1.0	0.5	-	7,740
Fruit & Veg.	1.23	1.0	1.0	-	420	420	-	1.0	1.0	-	520
Peppers	1.22	1.5	0.5	-	630	210	-	1.5	0.5	-	790
Others crops	1.20	1.0	-	-	6,000	-	-	1.0	0.11	-	7,200
Cotton	-	-	1.5	-	-	7,000	-	-	1.5	-	-
Sugarcane	-	-	-	-	-	1,300	2,600	-	-	-	-
Tobacco NPK	-	-	-	2	-	-	50	-	-	2	-
Other NPK	-	-	-	-	-	-	150	-	-	-	-
Total					49,310	13,000	2,800				59,920
						65,110					

	Fertilizer in qt/HA			1978/79 (tons)			1979/80 (tons)			1980/81 (tons)		
	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
Teff	1.0	0.27	-	36,000	9,720	-	43,560	11,760	-	5[illegible],700	14,230	-
Wheat	1.0	0.61	-	11,160	6,810	-	13,620	8,310	-	16,620	10,140	
Barley	1.0	0.27	-	7,730	2,090	-	9,350	2,520	-	11,310	3,050	
Maize	1.5	0.91	-	6,28[illegible]	3,830	-	7,660	4,660	-	9,350	5,690	
Sorghum	1.0	0.27	-	5,400	1,460	-	6,530	1,760	-	7,900	2,140	
Dagussa	1.0	-	-	4,490	-	-	5,430	-	-	6,570	-	
Pulses	1.0	-	-	7,44[illegible]	-	-	9,080	-	-	11,080	-	
Oilseeds	1.0	0.5	-	14,740	7,370	-	18,280	9,140	-	22,670	11,300	
Fruit & Veg.	1.0	1.0	-	970	970	-	1,190	1,190	-	1,460	1,460	
Pepper	1.5	0.5	-	1,430	480	-	1,740	580	-	2,120	710	-
Other crops	1.0	0.11	-	12,440	1,370	-	14,930	1,640	-	17,920	1,970	-
Cotton	-	1.5	-	-	14,530	-	-	17,430	-	-	20,920	-
Sugar cane	-	-	-	-	1,820	2,600	-	2,080	2,600	-	2,340	2,[illegible]
Tobacco NPK	-	-	2	-	-	210	-	-	250	-	-	[illegible]
Other NPK	-	-	-	-	-	310	-	-	370		-	4[illegible]
Total				108,080	50,450	3,120	131,370	61,070	3,220	15[illegible],700	7[illegible],950	4[illegible]
					161,650			195,660			[illegible],980	

SECTION I

Table 3

BASED ON A 20% GROWTH RATE PLUS AREA GROWTH

ns	Fertilizer in qt/HA			1975/76 tons			1976/77 tons			1977/78 tons		
	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
	1.0	0.11	-	20,300	2,240	-	24,600	2,700	-	29,770	3,270	-
	1.0	0.61	-	6,150	3,750	-	7,500	4,580	-	9,150	5,580	-
	1.0	0.11	-	4,070	450	-	4,920	540	-	6,390	7[illegible]	-
	1.5	0.91	-	3,460	2,110	-	4,220	2,570	-	5,150	3,140	-
	1.0	0.11	-	3,050	340	-	3,690	410	-	4,460	490	-
	1.0	-	-	2,540	-	-	3,070	-	-	3,710	-	-
	1.0	-	-	4,100	-	-	5,000	-	-	6,100	-	-
	1.0	0.5	-	7,740	3,870	-	9,500	4,800	-	11,890	5,950	-
	1.0	1.0	-	520	520	-	640	640	-	790	790	-
	1.5	0.5	-	790	260	-	960	320	-	1,170	390	-
	1.0	0.11	-	7,200	790	-	8,640	950	-	10,370	1,140	-
	-	1.5	-	-	8,400	-	-	10,100	-	-	12,100	-
,0	-	-	-	-	1,300	2,600	-	1,300	2,600	-	1,560	2,600
0	-	-	2	-	-	90	-	-	130	-	-	170
0	-	-	-	-	-	180	-	-	220	-	-	260
0				59,920	24,030	2,870	72,740	28,910	2,950	88,950	35,110	3,030
					86,820			104,600			127,090	

SECTION 2

80 (tons)		1980/81 (tons)			1981/82 (tons)			1982/83 (tons)			1983/84 (tons)		
UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
11,760		[illegible]	14,230	-	63,780	17,220		7,170	20,840	-	93,380	25,210	-
8,310	-	16,620	10,140	-	20,280	12,370	-	24,740	15,090	-	30,180	18,410	-
2,520	-	11,310	3,050	-	13,690	3,700	-	16,560	4,470	-	20,040	5,410	-
4,660	-	9,350	5,690	-	11,410	6,940	-	13,920	8,480	-	16,980	10,360	-
1,760	-	7,900	2,140	-	9,480	2,560	-	11,470	3,100	-	13,880	3,750	-
-	-	6,570	-	-	7,950	-	-	9,620	-	-	11,640	-	-
-	-	11,080	-	-	13,520	-	-	16,490	-	-	20,120	-	-
9,140	-	22,670	11,300	-	28,110	14,050	-	34,860	17,430	-	43,210	21,610	-
1,190	-	1,460	1,460	-	1,800	1,800	-	2,210	2,210	-	2,720	2,720	-
580	-	2,120	710	-	2,590	860	-	3,160	1,050	-	3,860	1,290	-
1,640	-	17,920	1,970	-	21,500	2,360	-	25,800	2,840	-	30,960	3,400	-
17,430	-	-	20,920	-	-	25,100	-	-	30,120	-	-	36,140	-
2,080	2,600	-	2,340	2,600	-	2,600	2,600	-	2,860	2,600	-	4,680	2,600
-	250	-	-	290	-	-	290	-	-	290	-	-	290
-	370		-	440	-	-	530	-	-	640	-	-	770
61,070	3,220	159,700	[illegible]	3,330	194,110	89,560	3,420	236,000	[illegible]	3,530	286,970	132,980	3,[illegible]
195,660			[illegible]			287,090			[illegible]			[illegible]	

TABLE 4

PROJECTIONS OF FERTILIZERS PRODUCT AND NUTRIENTS DEMAND

	D A P			U R E A		Sulphate of Ammonia SA		Total DAP+Urea+SA			NPK	Total
Year	Fert.	P_2O_5	N	Fert.	N	Fert.	N	Fert.	P_2O_5	N	Fert.	Fert.
74/75	49,310	22,680	8,880	13,000	5,980	2,600	550	64,910	22,680	15,410	200	65,110
75/76	59,920	27,560	10,790	24,030	11,060	2,600	550	85,760	27,560	22,400	270	86,820
76/77	72,740	33,460	13,100	28,911	13,300	2,600	550	104,250	33,460	26,400	350	104,600
77/78	88,950	40,920	16,010	35,110	16,150	2,600	550	126,560	40,920	32,770	430	127,090
78/79	108,080	49,720	19,460	50,450	23,210	2,600	550	159,810	49,720	43,220	520	161,650
79/80	131,370	60,430	23,650	61,070	28,090	2,600	550	193,570	60,430	52,290	620	195,660
80/81	159,700	73,470	28,750	73,950	34,020	2,600	550	236,250	73,470	63,320	730	236,980
81/82	194,110	89,290	34,940	89,560	41,190	2,600	550	284,550	89,290	76,680	820	287,090
82/83	236,000	108,560	42,480	108,490	49,900	2,600	550	345,290	108,560	92,930	930	348,020
83/84	286,970	132,010	51,650	132,980	61,170	2,600	550	419,150	132,010	113,370	1,060	423,610

TABLE 5

AMOUNTS OF FERTILIZERS TO BE USED AS MIXED FERTILIZERS x 1000 TONS

	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
Teff	24.6	[illegible]	36.0	59.0	60.0	73.3	88.7	107.5	129.2
Wheat	19.5	12.5	15.6	19.0	23.2	28.3	34.5	42.1	51.3
Barley	4.9	6.4	7.7	10.7	13.0	15.7	[illegible]	23.0	27.3
Maize	5.9	7.2	8.8	10.7	13.0	15.9	19.4	23.7	28.9
Sorghum	3.7	4.5	5.4	7.5	9.1	[illegible]	13.2	15.9	19.3
Oilseeds	11.6	14.4	17.8	22.1	27.4	34.0	42.2	52.3	64.8
Fruits & Vegetable	1.0	1.3	1.6	1.9	2.4	2.9	3.6	4.4	5.4
Peppers	1.0	1.3	1.6	1.9	2.3	2.8	3.5	4.2	5.2
MIK	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0
A. Max. to be used as mixed fertilizer	63.5	78.1	94.9	124.3	151.0	184.6	224.9	274.6	336.6
B. Assumed % of A	50	60	60	70	70	75	75	75	75
C. (A x B) Reduced amount to be used as mixed fertilizers	31.7	46.9	56.9	87.0	105.7	138.5	168.7	205.5	256.0

TABLE 6

PROJECTIONS BASED ON A 15% GROWTH NOTE + AREA GROWTH

	Growth rate	Requirement per HA in qt			Required fertilizer in tons 1974/75			Requirement per HA in qt			1975/76
		DAP	UREA	SA	DAP	UREA	SA				DAP
Teff	1.16	1.0	-	-	16,800	-	-	1.0	0.11	-	19,490
Wheat	1.17	1.0	-	-	5,040	-	-	1.0	0.61	-	5,900
Barley	1.16	1.0	-	-	3,360	-	-	1.0	0.11	-	3,900
Maize	1.17	1.5	0.5	-	2,840	950	-	1.5	0.91	-	3,320
Sorghum	1.16	1.0	-	-	2,520	-	-	1.0	0.11	-	2,920
Dagussa	1.16	1.0	-	-	2,100	-	-	1.0	-	-	2,440
Pulses	1.17	1.0	-	-	3,360	-	-	1.0	-	-	3,930
Oilseeds	1.19	1.0	0.5	-	6,240	3,120	-	1.0	0.5	-	7,430
Fruit Vegt.	1.17	1.0	1.0	-	420	420	-	1.0	1.0	-	490
Peppers	1.17	1.5	0.5	-	630	210	-	1.5	0.5	-	740
Other crops	1.15	1.0	-	-	6,000	-	-	1.0	0.11	-	6,900
Cotton	-	-	1.5	-	-	7,000	-	-	1.5	-	-
Sugar cane	-	-	-	-	-	1,300	2,600	-	-	-	-
Tobacco	-	-	-	2NPK	-	-	50	-	-	2NPK	-
Other NPK	-	-	-	NPK	-	-	150	-	-	-	-
					49,130	13,000	2,800				57,460
Total						65,110					

	Requirement per/HA in qt			1978/79			1979/80			1980/81		
	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
Teff	1.0	0.27	-	30,420	[illegible],210	-	35,290	9,530	-	40,930	[illegible]	-
Wheat	1.0	0.61	-	9,440	5,760	-	11,050	6,740	-	12,930	7,890	-
Barley	1.0	0.27	-	6,080	670	-	7,060	780	-	8,190	900	-
Maize	1.5	0.91	-	5,320	3,230	-	6,230	3,780	-	7,290	4,420	-
Sorghum	1.0	0.27	-	4,560	500	-	5,290	580	-	6,140	680	-
Dagussa	1.0	-	-	3,800	-	-	4,410	-	-	5,120	-	-
Pulses	1.0	-	-	6,300	-	-	7,370	-	-	8,620	-	-
Oilseeds	1.0	0.5	-	12,520	6,260	-	14,890	7,450	-	17,720	8,860	-
Fruit and vegetable	1.0	1.0	-	790	790	-	920	920	-	1,080	1,080	-
Pepper	1.5	0.5	-	1,180	390	-	1,380	460	-	1,620	540	-
Other crops	1.0	0.11	-	10,490	1,150	-	12,070	1,330	-	13,880	1,530	-
Cotton	-	1.5	-	-	1,453	-	-	17,430	-	-	20,920	-
Sugar cane	-	-	-	-	1,820	2,600	-	2,080	2,600	-	2,340	2,600
Tobacco	-	-	2NPK	-	-	210	-	-	250	-	-	290
Other NPK	-	-	-	-	-	310	-	-	370	-	-	440
				[illegible]	43310	3,120	105,960	51,080	3,220	123,520	60,210	[illegible],330
Total					[illegible],330			160,260			[illegible]7,060	

TABLE 6

...) ON A 15% GRO[illegible] NOTE + AREA GROWTH (SENSITIVITY TEST)

...izer 1974/75	Requirement per HA in qt			1975/76			1976/77			1977/78		
SA				DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
-	1.0	0.11	-	19,490	2,140	-	22,610	2,490	-	[illegible]	[illegible]	-
-	1.0	0.61	-	5,900	3,600	-	6,900	4,210	-	[illegible]	[illegible]	-
-	1.0	0.11	-	3,900	430	-	4,520	500	-	[illegible]	[illegible]	-
-	1.5	0.91	-	3,320	2,020	-	3,890	2,360	-	[illegible]	[illegible]	-
-	1.0	0.11	-	2,920	320	-	3,390	370	-	[illegible]	[illegible]	-
-	1.0	-	-	2,440	-	-	2,830	-	-	[illegible]	-	-
-	1.0	-	-	3,930	-	-	4,600	-	-	[illegible]	-	-
-	1.0	0.5	-	7,430	3,710	-	8,840	4,420	-	[illegible]	[illegible]	-
-	1.0	1.0	-	490	490	-	570	570	-	670	[illegible]	-
-	1.5	0.5	-	740	245	-	860	290	-	1,010	340	-
-	1.0	0.11	-	6,900	760	-	7,940	870	-	[illegible]	1,000	-
-	-	1.5	-	-	8,410	-	-	10,100	-	-	[illegible]	-
,600	-	-	-	-	1,300	2,600	-	1,300	2,600	-	1,500	[illegible]
50	-	-	2NPK	-	-	90	-	-	130	-	-	170
150	-	-	-	-	-	180	-	-	220	-	-	260
,800				57,460	23,425	2,870	66,950	27,480	[illegible]	78,010	32,510	3,030
					83,755			97,380			113,550	

...A	SA	1980/81 DAP	UREA	SA	1981/82 DAP	UREA	SA	1982/83 DAP	UREA	SA	1983/84 DAP	UREA	SA
[illegible]	-	40,930	[illegible]	-	[illegible]	[illegible]	-	[illegible]	[illegible]	-	[illegible]	17,250	-
[illegible]	-	12,930	7,890	-	15,130	9,230	-	17,700	10,800	-	20,710	[illegible]	-
[illegible]	-	8,190	900	-	9,500	1,040	-	11,020	1,210	-	12,780	1,410	-
[illegible]	-	7,290	4,420	-	8,520	5,170	-	[illegible]	6,050	-	[illegible]	7,080	-
[illegible]	-	6,140	680	-	7,120	790	-	8,260	910	-	[illegible]	[illegible]	-
	-	5,120	-	-	5,940	-	-	6,880	-	-	[illegible]	-	-
	-	8,620	-	-	10,080	-	-	11,700	-	-	[illegible]	-	-
[illegible]	-	17,720	8,860	-	21,090	10,540	-	25,090	12,550	-	[illegible]	[illegible]	-
[illegible]	-	1,080	1,080	-	1,260	1,260	-	[illegible]	1,470	-	[illegible]	[illegible]	-
[illegible]	-	1,620	540	-	1,890	630	-	2,210	740	-	[illegible]	[illegible]	-
[illegible]	-	13,880	1,530	-	15,960	1,760	-	18,350	2,020	-	[illegible]	[illegible]	-
[illegible]	-	-	20,920	-	-	25,100	-	-	30,120	-	-	[illegible]	-
[illegible]	2,600	-	2,340	2,600	-	2,600	2,600	-	2,860	2,600	-	[illegible]	[illegible]
	250	-	-	290	-	-	290	-	-	[illegible]	-	-	
	370	-	-	440	-	-	530	-	-	[illegible]	-	-	[illegible]
[illegible]	3,220	123,520	60,210	3,330	143,970	70,930	3,420	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			187,060			218,320			[illegible]			[illegible]	

TABLE 7

PROJECTIONS BASED ON A - 2[illegible] GROWTH NOTE + AREA G[illegible]

	Growth rate	Requirement in qt/HA			74/75 Requirement tons			Requirement in qt/HA			
		DAP	UREA	SA	DAP	UREA	SA				DAP
Teff	1.26	1.0	-	-	16,800	-	-	1.0	0.11	-	21,170
Wheat	1.28	1.0	-	-	5,040	-	-	1.0	0.61	-	6,450
Barley	1.27	1.0	-	-	3,360	-	-	1.0	0.11	-	4,270
Maize	1.27	1.5	0.3	-	2,840	950	-	1.5	0.91	-	3,610
Sorghum	1.27	1.0	-	-	2,520	-	-	1.0	0.11	-	3,200
Dagussa	1.26	1.0	-	-	2,100	-	-	1.0	-	-	2,650
Pulses	1.27	1.0	-	-	3,360	-	-	1.0	-	-	4,270
Oilseeds	1.29	1.0	0.5	-	6,240	3,120	-	1.0	0.5	-	8,050
Fruit and vegt.	1.28	1.0	1.0	-	420	420	-	1.0	1.0	-	540
Pepper	1.27	1.5	0.5	-	630	210	-	1.5	0.5	-	800
Other crops	1.25	1.0	-	-	6,000	-	-	1.0	0.11	-	7,500
Cotton	-	-	1.0	-	-	7,000	-	-	1.5	-	-
Sugar cane	-	-	-	-	-	1,300	2,600	-	-	-	-
Tobacco	-	-	-	2NPK	-	-	50	-	-	2NPK	-
Other NPK	-	-	-	-	-	-	150	-	-	-	-
					49,310	13,000	2,800				62,510
Total ...						65,110					

	Requirement in qt/HA			1978/9			1979/80			1980/1			D
	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA	
Teff	1.0	0.27	-	42,350	[illegible],660	-	53,350	5,870	-	67,230	7,390	-	84[illegible]
Wheat	1.0	0.61	-	13,530	8,250	-	17,320	10,560	-	22,170	13,520	-	[illegible]
Barley	1.0	0.27	-	8,740	2,360	-	11,100	3,000	-	14,100	3,810	-	17[illegible]
Maize	1.5	0.91	-	7,390	4,480	-	9,380	5,690	-	11,920	7,230	-	1[illegible]
Sorghum	1.0	0.27	-	6,560	720	-	8,330	920	-	10,570	1,160	-	1[illegible]
Dagussa	1.0	-	-	5,290	-	-	6,670	-	-	8,400	-	-	10[illegible]
Pulses	1.0	-	-	8,740	-	-	11,100	-	-	14,100	-	-	17[illegible]
Oilseeds	1.0	0.5	-	17,290	8,640	-	22,290	11,[illegible]0	-	28,760	14,380	-	37[illegible]
Fruit and vegetable	1.0	1.0	-	1,140	1,130	-	1,440	1,[illegible]0	-	1,850	1,850	-	
Pepper	1.5	0.5	-	1,640	550	-	2,080	[illegible]90	-	2,64[illegible]	880	-	[illegible]
Other crops	1.0	0.11	-	14,650	1,610	-	18,310	2,010	-	22,8[illegible]	2,520	-	[illegible]
Cotton	-	1.5	-	-	14,530	-	-	17,430	-	-	20,920	-	
Sugarcane	-	-	-	-	-	2,600	-	-	2,600	-	-	2,600	-
Tobacco	-	-	-	-	-	210	-	-	250	-	-	290	-
Other NPK	-	-	-	-	-	310	-	-	370	-	-	440	-
				127,410	4[illegible],930	3,120	161,370	[illegible],760	3,220	204,6[illegible]	23,660	3,330	2[illegible]
Total					177,460			[illegible]3,350			2[illegible]1,620		

... A - 2... GROWTH NOTE + AREA GROWTH (SENSITIVITY TEST)

...uirement tons	Requirement in qt/HA			1975/6			1976/7			1977/8		
SA				DAP	UREA	SA	DAP	UREA	SA	DAP	UREA	SA
-	1.0	0.11	-	21,170	2,330	-	26,670	2,[illegible]30	-	33,610	3,700	-
-	1.0	0.61	-	6,450	3,940	-	8,260	5,040	-	10,570	6,450	-
-	1.0	0.11	-	4,270	470	-	5,420	600	-	6,880	760	-
-	1.5	0.91	-	3,610	2,190	-	4,580	2,730	-	5,820	3,530	-
-	1.0	0.11	-	3,200	350	-	4,060	450	-	5,160	570	-
-	1.0	-	-	2,650	-	-	3,330	-	-	4,200	-	-
-	1.0	-	-	4,270	-	-	5,420	-	-	6,880	-	-
-	1.0	0.5	-	8,050	4,020	-	10,380	5,190	-	13,400	6,700	-
-	1.0	1.0	-	540	540	-	690	690	-	880	800	-
-	1.5	0.5	-	800	270	-	1,020	340	-	1,29[illegible]	430	-
-	1.0	0.11	-	7,500	830	-	9,380	1,[illegible]30	-	11,720	1,290	-
-	-	1.5	-	-	8,410	-	-	10,100	-	-	12,100	-
2,600	-	-	-	-	1,300	2,600	-	1,300	2,600	-	-	2,600
50	-	-	2NPK	-	-	90	-	-	130	-	-	170
150	-	-	-	-	-	180	-	-	220	-	-	260
2,800				62,510	24,650	2,870	79,210	30,450	2,950	100,410	36,410	3,030
					90,030			112,6[illegible]			139,850	

...EA	SA	1930/1			1981/2			1982/3			1983/4		
		DAP	UREA	SA	DAP	UREA	SA	DAP	...EA	SA	DAP	UREA	SA
...70	-	67,230	7,390	-	84,700	9,320	-	106,730	[illegible],740	-	134,480	14,790	-
...0	-	22,170	13,520	-	28,370	17,310	-	36,320	[illegible],150	-	64,490	28,360	-
...0	-	14,100	3,810	-	17,900	4,830	-	22,740	[illegible],140	-	28,880	7,800	-
...0	-	11,920	7,230	-	15,130	9,180	-	19,220	11,660	-	24,410	14,810	-
...0	-	10,570	1,160	-	13,430	1,480	-	17,050	[illegible],890	-	21,660	2,380	-
	-	8,400	-	-	10,590	-	-	13,340	-	-	16,810	-	-
	-	14,100	-	-	17,900	-	-	22,740	-	-	28,880	-	-
...0	-	28,760	14,380	-	37,090	18,550	-	47,850	[illegible]	-	61,730	30,860	-
...0	-	1,850	1,850	-	2,360	2,360	-	3,030	[illegible],030	-	3,870	3,870	-
...0	-	2,640	880	-	3,360	1,120	-	4,260	[illegible],420	-	5,410	1,800	-
...0	-	22,8[illegible]	2,520	-	28,610	3,150	-	35,760	[illegible],930	-	44,700	4,920	-
...0	-	-	20,920	-	-	25,100	-	-	[illegible]120	-	-	36,140	-
	2,600	-	-	2,600	-	-	2,600	-	-	2,600	-	-	2,600
	250	-	-	290	-	-	290	-	-	290	-	-	[illegible]
	370	-	-	440	-	-	520	-	-	640	-	-	770
...0	3,220	204,630	73,660	3,330	259,440	92,400	3,420	329,040	116,[illegible]00	3,530	435,320	145,770	[illegible]
...0			281,620			355,260			448,570			5[illegible],710	

SECTION 2

TABLE 8

COMPARISON DIFFERENT GROWTH RATES

	x 100 ton			Ratio	
	A 20%	B 15%	C 25%	B:A	C:A
1974/75	65.1	65.1	65.1	1.00	1.00
1975/76	86.8	83.8	90.0	0.96	1.04
1976/77	104.6	97.4	112.6	0.93	1.07
1977/78	127.1	113.6	139.9	0.89	1.09
1978/79	161.6	137.3	177.5	0.84	1.10
1979/80	195.7	160.3	223.4	0.81	1.14
1980/81	237.2	187.1	281.0	0.79	1.18
1981/82	287.1	218.3	355.3	0.76	1.24
1982/83	348.0	254.9	448.6	0.73	1.29
1983/84	423.6	297.8	584.7	0.70	1.38

TABLE 9

COMPARISON OF GERTSCH's AND OUR PROJECTIONS IN FERTILIZER PRODUCT x 1000 ton

	Projections Gertsch I			Projections Gertsch II adjusted			Ours (Imports 1967 - 1973, Projection 1975 - 1984)			
Year	D A P	Urea	Total	D A P	Urea	Total	D A P	Urea	Other	Total
1967	-						0.3	3.4	0.7	4.5
1968	-						0.9	2.0	0.3	3.2
1969	-						6.2	0.6	1.4	8.2
1970	-						5.9	0.6	3.6	10.1
1971	-						14.7	2.3	5.6	22.6
1972	10.8	5.0	15.8	10.8	5.0	15.8	13.7	3.2	0.5	17.4
1973	16.3	6.8	21.1	16.3	6.8	23.1	41.8	2.9	3.4	48.1
1974	24.6	9.7	34.3	24.6	9.7	34.3	n.a	n.a	n.a	n.a
1974/75	36.6	16.3	52.9	36.6	16.3	52.9	49.3	13.0	2.8	65.1
1975/76	49.4	26.8	76.2	36.6	16.3	52.9	60.0	24.0	2.9	86.8
1976/77	64.7	41.6	106.3	49.4	26.8	76.2	72.7	28.9	3.0	104.6
1977/78	83.8	61.7	145.5	64.7	41.6	106.3	89.0	35.1	3.0	127.1
1978/79	104.2	85.0	189.2	83.8	61.7	145.5	108.1	50.5	3.1	161.6
1979/80	124.4	110.0	234.4	104.2	85.0	189.2	131.4	61.1	3.2	195.7
1980/81	148.3	140.8	289.1	104.2	85.0	189.2	159.7	74.0	3.3	237.0
1981/82	171.9	173.5	354.4	124.4	116.0	274.4	194.1	89.6	3.4	287.1
1982/83	196.4	194.6	301.0	148.3	140.8	289.1	236.0	108.5	3.5	348.0
1983/84	211.7	210.8	422.5	171.9	173.5	345.4	287.0	133.0	3.7	423.6

TABLE 10

COMPARISON OF OUR AND GERTSCH'S PROJECTIONS IN TERMS OF NUTRIENTS x1000 TONS

	Gertsch I		Gertsch II adjusted		Ours	
Year	P_2O_5	N	P_2O_5	N	P_2O_5	N
1974/75	16.8	14.1	16.8	14.1	22.7	15.4
1975/76	22.7	21.2	16.8	14.1	27.6	22.4
1976/77	29.8	30.7	22.7	21.2	33.5	26.4
1977/78	38.5	43.5	29.8	30.7	40.9	32.8
1978/79	47.9	57.9	38.5	43.5	49.7	43.2
1979/80	57.2	73.0	47.9	57.9	60.4	52.3
1980/81	68.2	91.5	47.9	57.9	73.5	63.4
1981/82	79.1	101.7	57.2	73.0	89.3	76.7
1982/83	90.3	124.9	60.2	91.5	108.6	92.9
1983/84	97.4	135.1	79.1	101.7	132.0	113.4

CHAPTER IV

LOGISTICS AND DISTRIBUTION PATTERNS

IV- 1. Introduction

When the fertilizers are produced and bagged at Assab-Factory for the greater part they should be transported into the country to intermediate storages, to the definite farms or to M.P.P. Centres. In order to maximize the use of transport vehicles the transportation should preferably be evenly spread over a long period. The individual farmer has no means or is not willing to buy fertilizers long time in advance. This is one of the reasons, that intermediate storages on strategic spots in the country should be available. These intermediate or primary storages should be fed by the Assab-Factory and these in turn shall produce their own schemes to deliver fertilizers to smaller storages in villages and to individual farmers.

IV- 2. Transportation should be performed using trucks with trailers. The capacity of such a combination is 22 tons.

IV- 3. Suitable centres for primary storages are Addis Ababa, Nazareth and Asella where storages do exist or are under construction. These storages are respectively 10,000 tons, 5,000 tons and 5,000 tons. The towns mentioned are situated within reasonable distances from secondary centres (see figure 1). Moreover primary storage centres should be arranged for in Harrar, Dessie (alternatively Kombolcha and Woldya) and Massawa (alternatively Asmara). On the map the names of these primary storages are underlined.

IV-3.1. We were informed by Shell Oil Co., that an average velocity of 50 km per hour is feasible between Assab and many centres. Assuming velocities of 50 respectively 45 km we calculated some time schedules (see table 1 to 3). It was indicated by Shell that drivers prefer departure from Assab at about 15.00 in order to pass the hottest area in the afternoon. Time schedules were made for departures at 15.00 and at 06.00 and in some cases at 17.00. The schedules were set up assuming that the maximum driving time is 10 hours (with a few exception of 10½ - 11 hr, in order to be able to reach a suitable town for a night stop) and that a night stop should be at least 8 hours.

IV- 3.2. The schedules learn that:-

i. a roundtrip Assab-Addis Ababa-Assab has a duration of 4 days, independent of the time of departure from Assab. Average velocities of either 50 or 45 km per hour do not alter this schedule considerably.

ii. a roundtrip Assab-Nazareth-Assab takes 5 days at 50 km/hr and 4 days at 45 km/hr. Departure from Assab at 17.00 and an average velocity of 50 km leads to a 4 days roundtrip, assuming that no driving is done after 01.00.

iii. Roundtrips to Asella resp. Harrar ask for 4 days at both 50 and 45 km/hr as average velocities.

iv. the roundtrip Assab-Dessie-Assab can be performed in 2 days at 50 km/hr, whereas at a velocity of 45 km/hr it takes 3 days.

v. the roundtrip Assab-Kombolcha-Assab asks for 2 days both at 50 and 45 km/hr.

vi. the roundtrip Assab-Woldiya-Assab asks for 3 days both at 45 and at 50 km/hr average velocity.

IV- 3.3. The conclusions are that:-

a. Nazareth and Kombolcha are within short reach from Assab than Addis Ababa, Asella, Harrar and Woldya if an average velocity of 50 km/hr can be realised.

b. As Addis Ababa and Asella, have already an important function in the distribution of fertilizers their function should be continued, but if expansion is needed Nazareth should have preference.

c. A primary storage at Kombolcha is to be preferred to one at Dessie.

d. As Woldia is better situated to a number of north western and northern towns as is Dessie a primary storage should be arranged for in Woldia.

e. Transportation trucks should be able to achieve average velocities of 50 km/hr.

IV- 3.4. As to distribution in the north of the country either in Asmara or in Massawa primary storage facilities should be erected. As Assab-Asmara is 1136 km by road and Assab-Massawa even 100 km longer at least 6 days for a roundtrip are needed. A far better means of transport to this part of the country is sea transport by coasters from Assab to Massawa. Especially if the factory jetty is completed this is a convenient, cheap and quick way of transport. Coasters usually have capacities between 200 and 900 tons. In this case a primary storage at Massawa offers many advantages as either railway or road transportation is available to carry the bags to secondary storages.

Table 4 shows distances to primary and secondary storages.

IV- 4. <u>Transportation to primary storages by trucks.</u>

IV- 4.1. Production at Assab in 1977 will be according to different demand projections between 90,000 ton and 100,000 ton. For the following calculations it is assumed to be 100,000 tons.

Now 2 different distribution patterns are considered.
<u>In case 1</u> 15,000 ton per ship to Massawa, 45,000 tons on 4 days roundtrips (Addis Abeba, Asela, Harrar), 30,000 tons on 3 days roundtrips (Nazareth) and 10,000 tons on 2 days roundtrips (Kombolcha).
<u>In case 2</u>. 10,000 tons per ship plus 60,000 tons, 20,000 tons and 10,000 tons respectively on 4, 3 and 2 days roundtrips.

IV- 4.2. <u>Case</u> 1

15,000 tons by ship

45,000 tons per truck in 4 days trip	=	180,000 ton-days
30,000 " " " " 3 " "	=	90,000 " - "
10,000 " " " " 2 " "	=	20,000 " - "
		290,000 ton-days

Trucks with trailers with a capacity of 22 tons have to be used. Therefore, 13,200 truck days are necessary for the projected transport. Assuming a season of 220 days = 7.2 months 60 trucks can transport 85,000 tons, adding 20% for repairs, delays etc. 72 trucks are needed.

assuming transportation is done during 7 days per week (on a basis of 6 days 84 trucks are needed). If the distribution period is extended to a year (330 days) 40 trucks are needed or 48 including 20% contingencies. In the preceding calculation an even distribution over 220 or 330 days was presumed. There probably might be an uneven distribution pattern, for instance 75% of the yearly consumption in 220 days, the remainder 25% in 110 days. In this case 75% of 13,200 truck-days or 9,900 truck-days are handled in 220 days, and the remainder 3,300 in 110 days. This means the use of 54 trucks in the top season and 24 trucks in the remaining time (including 20% contingencies). So according to different patterns 78, 48 or 54 trucks are used as a maximum.

IV- 4.3. Case 2

10,000 tons by ship

60 000	tons per truck in	4	days trips	=	240,000	ton-days
22,000	" " "	3	" "	=	66,000	" "
8,000	" " "	2	" "	=	16,000	" "
					322,000	ton-days

Using truck-units of 22 tons this means 14,650 truck days or in a season of 220 days = 7.2 months 67 trucks. Adding 20% for delays, repairs etc. 80 trucks are needed.It is assumed transportation during 7 days per week (at 6 days per week 94 trucks are needed). If the distribution period is extended to a year, 45 trucks are needed, or 54 included 20% contingencies.

When as in case 1 an uneven distribution (75% in 220 days, 25% in 110 days) is supposed then 10,990 trucks days and 3,660 truck days are to be handled respectively in 220 and 110 days. This means the use of 60 respectively 40 trucks in said periods, 20% included for contingencies.

So according to different patterns 80, 54 and 60 trucks are needed simultaneously as a maximum.

IV- 4.4. Transportation by ship. Some trucks are needed for the transportation of 15,000 tons respectively 10,000 tons to Assab-Harbour as in 1977 the company's jetty will not yet be completed. However, the oil-refinery jetty, that offers ample depth for a coaster-ship, might be a useful substitute. In this case transportation can be made over shorter distances, but trucks are needed; whereas a well layed out jetty can handle the transport with belt conveyors. Assuming the use of truck and trailer units of 22 tons, the transportation of 15,000 tons asks for 690 roundtrips of 3 km each. Assuming 33 min each for loading and unloading, 24 min driving time (20 km/hr) and 6 min for extra's a roundtrip takes 1 hr 36 min. This corresponds to an hourly capacity of 13.75 tons per truck. A loading time of 33 min means that the lorry can be loaded directly from the output of a bagging unit. Using three trucks, one being loaded, one being unloaded and one en route, 40 tons per hour can be handled at the quai site, which is a good average rate of loading. A ship of 250 tons can thus be loaded in 6 hr 15 min, a ship of 800 tons in 20 hours. Transportation of 15,000 tons and 10,000 tons per ship will take respectively 375 and 250 hours and could be realised in 48 respectively 32 shifts of 8 hours. Three trucks are needed simultaneously.

IV- 5. Costs of Transportation

Little information could be obtained about the cost of transportation. We are informed by the Road Transport Administration that for the primary transport special contracts should be made. Because of the large quantities to be transported (case 1 and 2 resp. 85,000 and 90,000 tons) the price per quintal per km could be $0.007 - 0.008 or $0.07 - 0.08 per ton km. On the base of $0.07 some calculations were made. Return cargo's might result in lower price.

Case 1.	30,000 tons Addis Ababa (832 km)	=	24,960,000 t km
	10,000 tons Assab (794 km)	=	7,940,000 " "
	5,000 tons Harrar (928 km)	=	4,640,000 " "
	45,000 tons (4 day trips)	=	37,540,000 t km
	18,000 tons to Nazareth (723 km)	=	13,014,000 t km
	12,000 tons to Woldia (629 km)	=	7,548,000 t km
	30,000 tons on 3 day trips	=	20,562,000 t km
	10,000 tons to Kombolcha (487 km)	=	4,870,000 t km

Total 62,972,000 tons km.
Costs at $0.07 = $4,408,000

Case 2.	50,000 tons to Addis Ababa (832 km)	=	41,600,000 t km
	15,000 tons to Assab (794 km)		11,912,000 " "
	5,000 tons to Harrar		4,680,000 " "
	70,000 tons on 4 day trips		58,192,000 t km
	14,000 tons to Nazareth (723 km)		10,126,000 t km
	8,000 tons to Woldia (629 km)		5,032,000 " "
	22,000 tons on 3 day trips		15,158,000 t km
	8,000 tons to Kombolcha (487 km)		3,896,000 t km

Total 77,246,000 tons km
Costs at $0.07 = $5,407,200

The costs of the secondary and tertiary transportation cannot be calculated as there are too many unknown factors.

Transportation by ship has to be studied separately.

IV- 6. Transportation to secondary and tertiary storages.

The secondary centres as mentioned in annex 5 are supposed to be fed from the primary centres and these in turn supply the tertiary storages and part of the consumers. The tertiary stores deliver to the farmers. The majority of the secondary centres are situated within 500 km from the primary storage centres. In those depending on the Woldia storage some are at larger distances. So the majority can be reached in one or two day roundtrips. Not many will need a three day roundtrip. Not much can be said about the number of trucks to be needed for the secondary distribution. The following unknown factors prevent at present to achieve a solution.

i. The amounts of fertilizer to be distributed to the secondary centres are as yet unknown.

ii. It might very well be that more secondary centres are wanted.

iii. The implementation of new primary and secondary roads might alter the pattern.

It can however be said that because of the shorter average distances between primary and secondary storage as compared with those between the Asab-factory and the primary storage centres the number of trucks to be used will be less. To feed the primary storages between 80 and 48 trucks are needed. A rough guess is that between 50 and 30 trucks be needed for the secondary and tertiary transport. However, an accurate plan can only be made if the distribution patterns be known in details.

IV- 7. Transportation patterns

Some doubts were expressed whether transportation from the factory to the inland storages should be possible regularly. In that case a large storage at the factory site should be considered. However when studying transportation patterns it becomes obvious that as soon as possible after bagging the products should be loaded on trucks and conveyed. Such a practice not only minimizes handling of bags but delays in transportation have an adverse effect on the number of trucks needed and of the capacity needed for storage of bags.

Calculations were made on the basis of monthly productions of 14,000 tons during 7 and 11 months respectively resulting in yearly productions of 98,000 tons and 154,000 tons. These are roughly the volumes that should be reached in 1976/77 and 1978/79 respectively.

Case 2 (Chapter IV-4.3) was used as the basis for calculations; 90% of total volume should be transported by road, average time of round trips is 3.6 days. Patterns of transportation during 6 respectively 7 days per week were considered. The tables present the number of trucks and the storage needed for bagged materials.

Table IV-5

No. of months for Transport	Bags to be Stored x 1000 ton	Transp. 6 days/week Trucks/Day	Transp. 6 days/week Total No. of trucks + 20%	Transp. 7 days/week Trucks/Day	Transp. 7 days/week Total No. of trucks +20%
Production during 7 months (21[illegible] days) at 14000 t/month					
2	70	77	333	67	283
4	42	[illegible]	166	33	142
6	14	26	112	22	95
7	minimal	22	95	19	82

Table IV-6

No. of months for Transport	Bags to be Stored x 1000 ton	Transp. 6 days/week Trucks/Day	Transp. 6 days/week Total No. of trucks + 20%	Transp. 7 days/week Trucks/Day	Transp. 7 days/week Total No. of trucks +20%
Production during 11 months (334 days) at 14000 t/month					
3	112	81	350	70	302
6	70	41	177	35	151
9	28	27	117	23	100
11	minimal	22	95	19	82

Conclusion is that the truck fleet needed to transport bagged fertilizer into the country is minimal when transportation is done during the whole time of production. Deviations from this pattern result in a fast growing number of trucks to be loaded per day and a larger fleet to handle the transportation. It must be kept in mind that the number of trucks that can be handled by one shift of 2 crews is 3.6 trucks of 22 tons each per hour or 25 trucks/day (7 hrs). This is the combined output of the two bagging units (80 t/hr) directly loaded to the trucks. It might be easier to charter a moderate number of trucks for a long and uninterrupted period than a large number for short periods. Such a fleet of trucks could be owned by the fertilizer company, by a closely related body or by an entirely independant enterprise. It is beyond the scope of this study to advice about this problem.

The tables show that large storages for bagged fertilizers are needed even for slightly retarted transportation schemes. A 28,000 ton storage would cost $910,000. A 10,000 ton storage is foreseen ($325,000, Chap. VII-Annex 5) and is able to meet all irregularities from the schedules in which production and transportation are simultaneous.

Fig. IV-2 and 3 illustrate the above mentioned schedules.

IV - 8. Conclusions

Transportation to the primary storages as mentioned in Chapter 5-3.1 is rather sensitive as to the distribution pattern and the time schedule. For the transportation of 100,000 tons of fertilizer a fleet of trucks varying between 48 and 80 is needed; the exact number depending upon the pattern. In this case transportation is during 7 days per week. If 5 days per week are available the number of trucks is 56 to 94. It is assumed that in this pattern 15,000 tons or 10,000 tons are used in the northern part of the country. These quantities are preferably transported by coaster ships to Massawa. Loading time of these quantities amount to 375 and 250 hours respectively. So long as a company's jetty with modern facilities is not available, three trucks plus trailers are needed for transportation of bagged fertilizers from the factory to Assab Harbour.

Transportation of bagged fertilizer should be done covering the whole time of production.

Table IV - 1

Assab - Addis Ababa - Assab (4 days)

			50 km/hr					45 km/hr			
Assab	1	D	15.00	17.00	06.00	1	D	15.00	06.00	Assab	1
Mile	1	A		23.00 NS		1				Mile	1
Mile	2	D		07.00						Mile	2
Gewane	1	A	24.00 NS		15.00 NS	1	A	01.00 NS	16.00 NS	Gewane	1
Gewane	2	D	08.00		06.00	1	A	09.00	06.00	Gewane	[illegible]
Addis Ababa	2	A	15.30 NS.U	17.30 NS.U	13.30 U	2	A	17.30 NS.U	14.30 U	Nazereth	[illegible]
Addis Ababa	3	D	06.00	06.00	15.30	3	D	06.00	16.30	Nazereth	[illegible]
Nazereth	2	A			17.30 NS	2	A		18.45 NS		
Nazereth	3	D			06.00				06.00	Gewane	[illegible]
Gewane						3	A	14.30 NS		Gewane	[illegible]
Gewane						4	D	06.00			
Mile	3	A	16.30 NS	16.30 NS		3	A		15.30 NS	Mile	
Mile	4	D	06.00	06.00		4	D		06.00	Mile	
Serdo	3	A			15.45 NS					Serdo	[illegible]
Serdo	4	D			06.00					Serdo	[illegible]
										Assab	[illegible]
Assab	4	A	12.00	12.00	10.00	4	A	16.00	12.45	Assab	[illegible]

Legend: NS = Night stop
U = Unloading

Table IV - 1

days) | Assab - Nazereth - Assab (3 or 4 days)

45 km/hr					50 km/hr					45 km/hr	
15.00	06.00	Assab	1	D	15.00	17.00	16.00	1	D	15.00	06.00
		Mile	1	A		23.00					
						NS					
		Mile	2	D		07.00					
01.00	16.00	Gewane	1	A	24.00		15.00	1	A	01.00	16.00
NS	NS				NS		NS			NS	NS
09.00	06.00	Gewane	2	D	08.00		06.00	2	D	09.00	06.00
17.30	14.30	Nazereth	2	A	13.30	16.30	11.30	2	A	15.15	12.15
NS.U	U				U	NS.U	U			U.NS	U.NS
06.00	16.30	Nazereth	2/3	D	15.30	06.00	14.00	3	D	06.00	06.00
	18.45 NS										
	06.00	Gewane	2	A	21.00 NS		19.30 NS				
14.30 NS		Gewane	3	D	06.00		06.00				
06.00											
	15.30 NS	Mile						3	A	15.30 NS	15.30 NS
	06.00	Mile						4	D	06.00	06.00
		Serdo	3	A		15.45 NS					
		Serdo	4	D		06.00					
		Assab	3	A	15.00	-	15.00				
16.00	12.45	Assab	4	A	-	10.00	-	4	A	12.45	12.45

Table IV-2

Assab - Asela - Assab (4D)

			50 km/hr						
Assab	1	D	15.00	17.00	06.00	1	D	15.00	06.00
Mile	1	A		23.00 NS					
Mile	2	D		07.00					
Gewane	1	A	24.00 NS		15.00 NS	1	A	01.00 NS	16.00 NS
Gewane	2	D	06.00		06.00	2	D	09.00	06.00
Asela	2	A	15.00 U	17.00 U	13.00 U	2	A	16.30 U	13.30 U
Asela	2/3	D	17.00	06.00	15.00	2	D	18.30	16.30
Nazereth	2	A	18.15 NS		16.15 NS	2	A	20.00 NS	18.00 NS
Nazereth	3	D	06.00		06.00	3	D	06.00	06.00
Mile	3	A		15.45 NS		3	A	15.30 NS	15.30 NS
Mile	3	D		06.00		4	D	06.00	06.00
Serdo	3	A	15.45 NS		15.45 NS				
Serdo	4	D	06.00		06.00				
Assab	4	A	10.00	12.00	10.00	4	A	12.45	12.45

Assab	
Gewane	
Gewane	
Harrar	
Harrar	
Gewane	
Gewane	
Assab	

Table IV-2

15.00	06.00
01.00	16.00
NS	NS
09.00	06.00
16.30	13.30
U	U
18.30	16.30
20.00	18.00
NS	NS
06.00	06.00
15.30	15.30
NS	NS
06.00	06.00
12.45	12.45

Assab - Harrar - Assab (4D)

			50 km/hr				45 km/hr	
Assab	1	D	15.00	06.00	1	D	15.00	06.00
Gewane	1	A	24.00	15.00	1	A	01.00	16.00
			NS	NS			NS	NS
Gewane	2	D	06.00	06.00	2	D	09.00	06.00
Harrar	2	A	17.30	15.30	2	A	19.30	16.30
			U.NS	U.NS			U.NS	U.NS
Harrar	2	D	06.00	06.00	3	D	06.00	06.00
Gewane	3	A	15.30	15.30	3	A	16.30	16.30
			NS	NS			NS	NS
Gewane	4	D	06.00	06.00	4	D	06.00	06.00
Assab	4	A	15.00	15.00	4	A	16.00	16.00

Table IV - 3

Assab - Dessie - Assab (2 or 3 days)

			50 km/hr				45 km/hr	
Assab	1	D	15.00	06.00	1	D	15.00	06.00
Bati					1	A	01.00 NS	16.00 NS
Bati					2	D	09.00	06.00
Dessie	1	A	01.00 U.NS	16.00 U.NS	2	A	10.30 U	07.30 U
Dessie	2	D	9.00	06.00	2	D	13.00	09.30
Serdo					2	A	21.30 NS	18.30 NS
Serdo					3	D	06.00	06.00
Assab	2	A	19.00	16.00	3	A	10.30	10.30

Assab	1
Bati	
Bati	
Dessie	1
Dessie	2
Woldia	2
Woldia	2
Mile	2
Mile	3
Assab	3

Assab - Kombolcha - Assab (2 days)

			50 km/hr				45 km/hr	
Assab	1	D	15.00	06.00	1	D	15.00	06.00
Kombolcha	1	A	0.30 U.NS	16.00 U.NS	1	A	01.45 U.NS	16.45 U.NS
Kombolcha	2	D	03.30	06.00	2	D	10.00	06.00
Assab	2	A	18.00	15.30	2	A	20.45	16.45

Table IV - 3

ys)

45 km/hr	
.00	06.00
1.00	16.00
S	NS
.00	06.00
.30	07.30
	U
.00	09.30
.30	18.30
	NS
.00	06.00
0.30	10.30

Assab - Woldia - Assab (3 days)

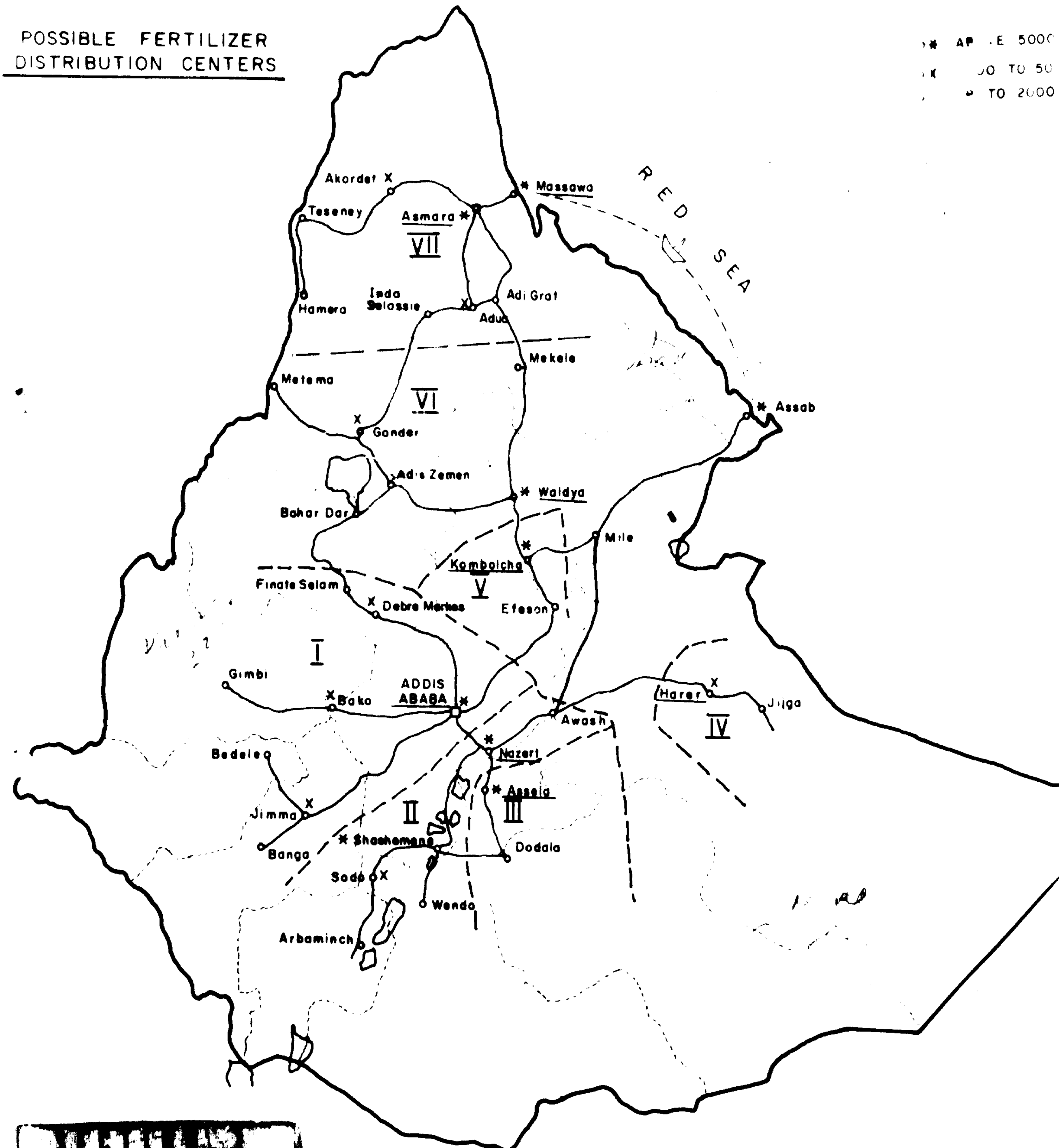
			50 km/hr				45 km/hr	
Assab	1	D	15.00	06.00	1	D	15.00	06.00
Bati					1	A	01.00 NS	16.00 NS
Bati					2	D	09.00	06.00
Dessie	1	A	01.00 NS	16.00 NS				
Dessie	2	D	09.00	06.00	2			
Woldia	2	A	11.30 U	8.30 U	2	A	13.00 U	10.00 U
Woldia	2	D	13.30	10.30	2	D	15.00	12.00
Mile	2	A	20.00 NS	17.00 NS	2	A	22.00 NS	19.00 NS
Mile	3	D	06.00	06.00	3	D	06.00	06.00
Assab	3	A	12.00	12.00	3	A	12.45	12.45

45 km/hr	
00	06.00
45	16.45
IS	U.NS
00	06.00
45	16.45

Table IV-4

Primary storages to be supplied from Assab-factory Distances from Assab	Secondary storages to be supplied from primary storages Distances from primary storages	Tertiary storages
I. Addis Ababa 832 km	Bako 242 km Jimma 335 km Debre Markos 302 km	Gimbi Bedele, Bonga Finote Selam Debre Berhan
II. Nazereth 733 km	Shashamene 198 km Awash 125 km	Sodo, Arbaminch, Wondo
III. Asela 794 km	Dodole 130 km	Robe
IV. Harar 928 km	-	Jijiga
V. Kombolcha 487 km	Efeson 91 km	Dessie
VI. Woldya 629 km	Bahr Dar 302 km Gondar 300 km Mekele 258 km	Addis Zemene Metema (609 km)
VII. Massawa by sea: 500 km	by train to Asmara 100 km Akordat 270 km by road to: Asmara 100 km Akordat 273 km Adwa 257 km	Teseney, Humera Inda Selassie, Adigrat

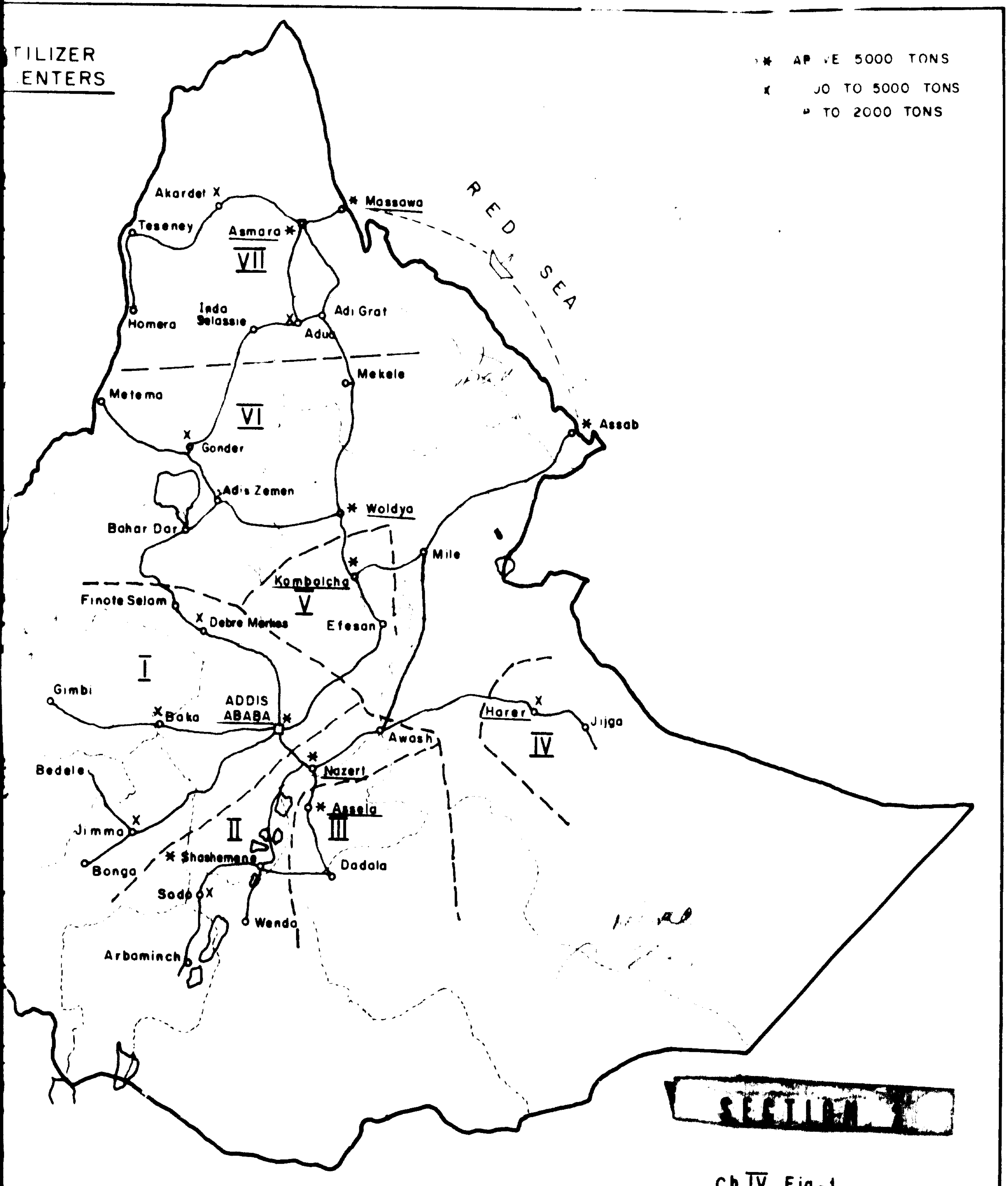
Distance	Assab - Serdo	=	207 km
"	Assab-- Milo	=	303 km
"	Assab - Gewane	=	453 km
"	Assab - Bati	=	445 km



POSSIBLE FERTILIZER DISTRIBUTION CENTERS

Ch IV Fig-1

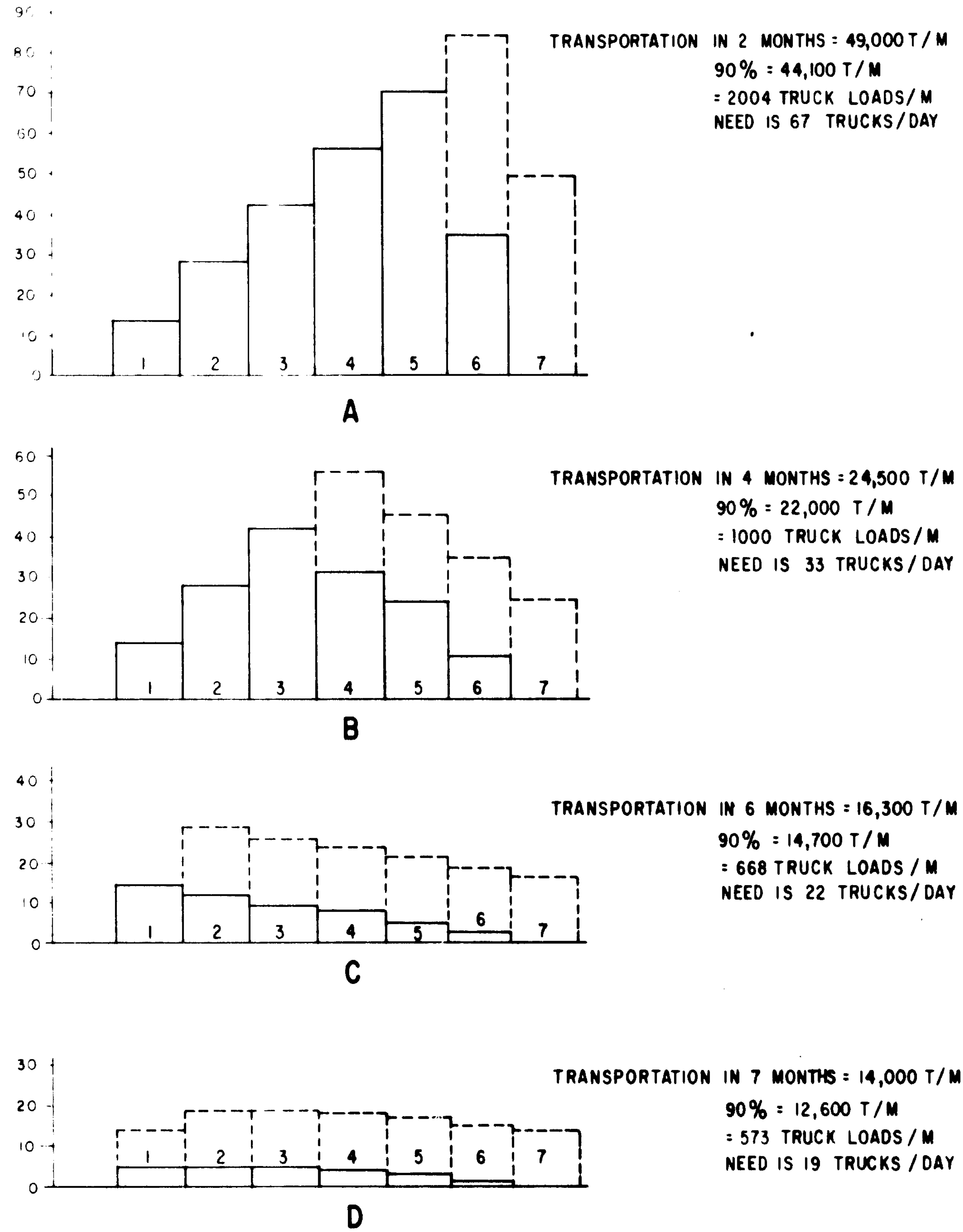
TILIZER
ENTERS



SECTION

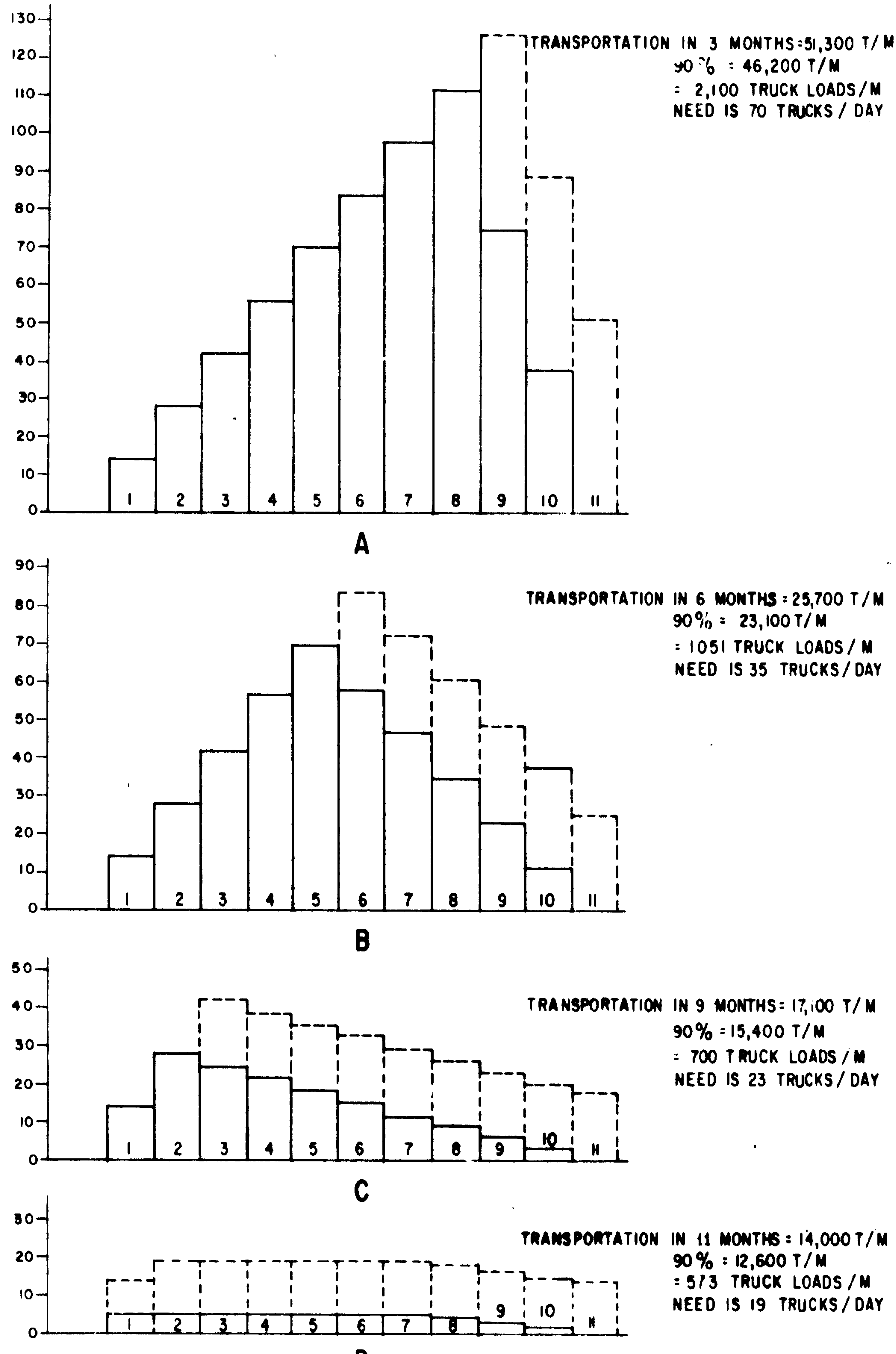
Ch IV Fig-1

PRODUCTION 98,000 T IN 7 MONTHS = 14,000 T/M



Ch IV Fig - 2

PRODUCTION 154,000 T IN 11 MONTHS = 14,000 T/M



Ch IV Fig-3

CHAPTER V

PHASES OF FERTILIZER MANUFACTURE IN ETHIOPIA

V- 1. Introduction

When fertilizer production grows beyond certain limits it will be profitable to produce within the country some fertilizer products that now are imported. Production can be done either from imported and available local raw materials or from imported intermediates.

An important factor is the situation of the factory relative to harbour facilities. A jetty on the factory site might be of utmost importance, as it greatly reduces problems of transportation from ship to factory site. As to the economic feasibilities of local production it must be stated that these largely depend on prices of raw materials and intermediates as well as on freightcosts. At present these costs are rather unstable and subject to significant changes. Therefore feasibility studies should be carried out and adapted to current prices at regular intervals. The main purpose of this chapter is to give a broad survey of the problems. The feasibility studies, that are rather time consuming, have to be made seperately and in depth.

V- 2. The main products to be used in mixes and as straight fertilizers are diammonium phosphate (DAP) and urea. The demand projections (Chapter III) foresee the following needs for DAP and urea.

Table V-1 x 1000 tons

Year	DAP	UREA	nutrients in DAP P_2O_5	nutrients in DAP N	N in Urea	Total N incl. S.
1974/75	49.3	13.0	22.7	8.9	6.0	15.4
1975/76	60.3	23.2	27.8	10.8	10.7	22.0
1976/77	72.8	29.1	33.5	13.1	13.4	27.0
1977/78	89.0	34.0	40.9	16.0	15.6	32.2
1978/79	108.1	49.1	49.7	19.5	22.6	42.6
1979/80	131.4	59.6	60.4	23.7	27.4	51.6
1980/81	159.7	72.4	73.5	28.7	33.3	62.6
1981/82	194.1	87.8	89.3	34.9	40.4	75.9
1982/83	236.0	106.7	108.6	42.5	49.1	92.1
1983/84	287.0	129.6	132.0	51.7	59.6	111.8

At certain levels the production of intermediates and fertilizers from a technological point of view starts to be feasible. For the products and intermediates we have to consider a set up of a phasing scheme.

V- 3. Phase I

Bagging and Mixing Plant

This plant is to be implemented soon. It has been shown that a saving of US $22.- per ton (1974) of fertilizer does exist as compared with import of bagged products. The plant will contain one bulk blending unit of 40 ton hourly capacity as well as 2 bagging units of 40 ton/hr capacity each. Depending on the length of the production season (220 days upto 330 days) and of the number of shifts (1 to 3) this plant has a yearly capacity of 70,000 to 300,000 tons of mixed fertilizers. Its bagging capacity is twice as large. Materials to be mixed and to be bagged as straight fertilizers mainly are DAP and urea. Smaller amounts of sulphate of ammonia, potassium chloride are to be used as well. The use of triple superphosphate might be foreseen. A storage for raw materials to contain 15,000 tons equipped with a bucket elevator and belt conveyor for handling materials is needed.

Although it is advantageous to transport bagged fertilizers to inland storages immediately after production this cannot be done under all circumstances. Therefore a storage for bagged products is foreseen. Its capacity is 10,000 tons. As mentioned the mixing and bagging units have large capacities and can meet the needs upto 1983/84. For economic reasons however it is reasonable to consider to produce the raw materials for the mixing plant at the factory site as well as the possibility of looking into the production of other types like NP and NPK fertilizers.

All materials mentioned have to be imported and in the first stages ships carrying these products have to be unloaded at Assab-Harbour. Port facilities at Assab-Harbour are limited. No harbour cranes are available at present and unloading of ships should be done using the ships gear. Even when grabs and hoppers are provided for by the company unloading rates will not be high. Assuming an average type of ship's gear 80 tons per hour can be unloaded. A fleet of 8 tipping trucks is needed to transport material from the port to the factory covering a distance of about 4 km. At an importation rate of 100,000 tons a year these transportation costs will be E$1.35/ton. (see Chap. XI-2.21)

V- 4. Phase II

The production of diammonium phosphate at volumes from 60,000 t/year upwards is realised in some countries. This level will be reached in this country in 1976. In the majority of cases a DAP production unit of such a limited capacity is operated if sufficient supply of phosphoric acid and of ammonia was available. To produce 60,000 tons of DAP one needs about 12,000 ton of N or 15,000 tons of ammonia and about 30,000 ton of P_2O_5 in phosphoric acid. Both quantities are too small to justify production in Ethiopia. Therefore both should be imported.

V- 4.1. Ammonia is now readily available as a liquified gas and is transported in special ships at - 33°C under normal atmospheric pressure. Principal ports for ammonia are in Kuwait, Trinidad and Algeria. Shiploads are about 8,500 m tons. Ships are equipped to maintain the low temperature of liquified ammonia. The tanks are discharged in 12 hours using the ships equipment which at an hourly rate of about 700 tons or 1000 m^3 (SW ammonia at - 33°C = 0.68) or of 17 m^3 per min. To meet this high unloading rate storage tanks have to be installed at short distance from the quai. This distance should not exceed 200 m. In order to maintain the low temperature the pipeline should be well insulated and its cross section should be sufficient to allow the ship's pumps to overcome the loss of head in the pipeline. Calculations show that an 8" pipeline of 200 m length when conveying 700 tons of ammonia per hour has a pressure drop of 0.7 atm, which is admissable. The same pipeline to the factory should have a length of 4 km and the loss of head would be 14 atm, which is prohibitive, Moreover such a long and wide pipeline has a holdup capacity of 125 m^3, which is very high.

There are two methods to store liquified ammonia. One method is to store at low temperature (-33°C) under normal atmospheric pressure; the other one is at ambient temperature. In Assab with expected temperatures of 40°C, the corresponding pressure is 15 atm. Storage at ambient temperature can be done in Horton tanks of spherical shape.

These Hortonsphere have a limited capacity and 2,500 t is the maximum. This means that 4 to 5 of these tanks have to be installed to hold a shipload plus the stock that has to be available to ensure uninterrupted production. As an alternative storage can be done in an atmospheric tank at low temperature. This has several advantages as compared with Horton-spheres. In this case one tank of 12,000 m^3, which has proved to be an economical size is sufficient. The tank should be well insulated to keep the temperature at the desired low level. The ammonia vapour from the tank is compressed, cooled, liquified and recycled. The costs of such a storage tank including compressors, insulation, buildings etc was US$670,000 in 1966. Costs now will be US$1,100,000 or G$2,300,000. About 0.5 Ha of land is needed. It must be kept in mind that about 50% of the costs are for insulation, foundation, building etc. Therefore moving of the installation, to another site is hardly possible from an economic point of view. When conveying the liquid ammonia to the factory the temperature should be raised to normal using a heat exchanger with steam or hot water as the heating medium. Transportation of refrigerated ammonia through a long pipeline is troublesome as the internal friction heats the liquid which results in the formation of vapours. Storage at factory-site can be done in one Horton-sphere of 2,500 tons at ambient temperature. Supply from the storage at the port-site can be done gradually. Therefore a small diameter pipeline, able to withstand medium pressure (20 atm) is sufficient.

If ships can moore at a factory jetty neither the long pipeline with pumping station nor the secondary storage in a Horton-sphere are necessary and an atmospheric storage at the factory site is sufficient. In case the factory jetty is built at a later time it is hardly possible to rebuild the atmospheric storage at the factory site at reasonable costs. Some manufacturers of ammonia storage installations are listed below:-

Pechiney - St. Gobain, France
Kellogg Co. USA
Chemico, USA
Stamicarbon, Holland
Montedison, Italy
Mitsui, Japan

V- 4.2. Phosphoric acid can be obtained in shiploads as a liquid containing 54% P_2O_5 - (equivalent to 75% H_3PO_4). Another product is superphosphoric acid with 76% P_2O_5; this liquid contains polyphosphoric acids and has a very high viscosity. It is therefore difficult to handle, moreover it has to be transformed into orthophosphoric acid (H_3PO_4) before processing to DAP and similar products. Price is higher than the 54% acid, but lower transportation costs could compensate for this.

Phosphoric acid can be obtained from N-Africa (Morocco, Tunesia, Algeria) and from U.S.A. (Florida). Shiploads are about 8000 - 9000 tons containing about 4,500 tons of P_2O_5 and having a volume of 5100 - 5700 m^3. Long distance transport (4 km) of phosphoric acid through a pipeline is not feasible due to its corrosive nature and to its tendency to form deposits which would clog the pipeline. Therefore, a storage near the discharge quai is necessary. The connecting pipeline can then be made out of corrosion resistant material and cleaning of the short pipe is feasible.

Storage capacity of 7,500 m^3 is required in order to ensure an uninterrupted production of DAP. Five rubber lines steel tanks with a dimension of 15 m. in diameter and 9 m in height could handle this volume. The rubber lining operation is carried out after erection.

Short distance transportation of phosphoric acid should be done in rubber lined tank-trucks. In 1976 roughly 55,000 tons (36,000 m^3) of product have to be transported. This figure will increase to 82,000 or 53,000 m^3 by 1978. Assuming the use of tank-trucks of 12 tons capacity 4000 truck loads per year or 21 per day are needed in 1976. Assuming a roundtrip of 1.5 hours, one truck can transport 170 tons per day in 3 shifts (21 hours). (A roundtrip is 24 min driving. 30 min loading 30 min unloading and 6 min miscellaneous)

The ship has to unloaded in 3-4 days (72-96 hrs). To transport 9000 tons in this time a fleet of 15-19 trucks (one as standby) is needed, one extra tank to enable a continuous discharge of the ship will also be needed. If tanks are available at port site only two tanktrucks are necessary for transportation to the factory.

V- 4.3. A diammonium factory of 60,000 tons per season (or 260 tons/day) is a feasible unit. Round the year operation will increase this capacity to 86,000 tons. Raw materials used are ammonia and phosphoric acid. When using a mixture of phosphoric acid and sulphuric acid a compound fertilizer, ammonium sulphate phosphate (ASP) with a grade 19:38:0, can be made directly. Current investment costs will be about E$2,500,000 (1967 Fertilizer Manual) whereas a plant of about 120,000 ton capacity (520 t/day) will now cost about E$4,000,000 (see Chapter V-5.1). Such a plant has a capacity of 172,000 tons when run for 330 days per year. A storage for 10,000 tons of DAP should be provided for. Some manufacturers of DAP plants follow:-

Pechiney - St. Gobain, France
Dorr Oliver, USA
Nissan, Japan
Stamicarbon, Holland
Lurgi, W/Germany

V- 4.4. The transportation of phosphoric acid is cumbersome and a storage at port site is costly or a large fleet of rubber lined tank trucks is required. Moreover none of the facilities (ammonia storage, phosphoric acid storage DAP factory) could possibly be on stream in either 1976 or 1977. Therefore the situation in 1978 should show important leads for further plans. We shall see that the consequences are to bypass phase II and proceed directly to phase III.

V- 5. Phase III

5.1. Phase III implies the production of phosphoric acid from the raw materials phosphate rock and sulphur; sulphuric acid being an intermediate. Ammonia should be imported as in Phase III.

Phase III can be considered when 50,000 tons of P_2O_5 are needed in phosphoric acid. This means about 100,000 tons of DAP. This level is reached in 1978/79. Phosphoric acid demand in 1982 will be over 90,000 tons of P_2O_5.

5.2. To produce 1 ton of P_2O_5 in phosphoric acid about 1 ton of sulphur and 3.4 tons of rock phosphate (31% P_2O_5) are needed. As an intermediate 2.9 tons of sulphuric acid are used. As a byproduct 4.5 tons of waste gypsum is produced.

5.2.1. Disposal of this waste gypsum is a necessity. Although there do exist methods to use this byproduct they are seldom realised and disposal is the most economical way to deal with the waste gypsum. The cheapest way to dispose of is evacuating into the sea, but this is only permitted when strong sea currents continuously can carry the gypsum away. In a heavy turbulent current the gypsum dissolves. But in a slow stream it is only carried away and later on settles on the bottom of the sea and on the shores thus causing environmental hazards. Near Assab the sea currents are about 2 knots or 3.7 km/hour with intervals of no currents. Therefore disposal in the sea near the coast is not admissible. This leaves two possibilities, namely either disposal on an empty site near the plant, which in our case will be easily available or transportation into the deep sea using lighters equipped with bottom discharge devices. The first method is to be preferred.

Some processes do exist to process waste gypsum to other products. From an economical point of view most of them are not feasible. An exception is the production of gypsum building blocks and panels for inner walls providing a nearby market exists.

Other possibilities are the production of cement plus sulphuric acid, the latter product can be recycled and of processing it in sulphate of ammonia plus calcium carbonate. As said before these processes do not offer economical sound solutions.

V- 5.2.2. Another waste product from phosphoric acid factories are fluorine compounds in the gaseous **effluents**. As these are noxious and corrosive gases, they should be removed. This can be done by washing with sweet water. The solution thus obtained can be either evacuated into the sea or better be treated with a solution of common salt, thus precipitating a fluorine salt (sodium silicofluoride) that at present hardly can be marked. As most rock phosphates contain 3-4% of fluorine, about half of which is contained in the exit gases, 50-60 kg of fluorine per ton of P_2O_5 in phosphoric acid has to be removed. Methods to produce valuable fluorine compounds from the wastes, are being studied and used on a limited scale. But for the time being a well established process is hardly available.

V- 5.3. Assuming a production unit of 75,000 ton P_2O_5 per year or 225 ton/day when run on a round the year basis (330 days) a sulphuric acid plant of 225,000 tons capacity (680 t/day) implies the need for a storage of sulphur of about 12,000 tons or 9,000 m^3 (apparent specfic weight is 1.3-1.4) as well as a storage for sulphuric acid. A covered storage for 18,000 ton phosphate rock is also needed. Apparent specific weight being 1.8 a 10,000 m^3 storage can hold 18,000 t. Costs of a 75,000 ton phosphoric acid plant are estimated to be E$8,000,000. Costs for a 225,000 t sulphuric acid plant are estimated to be E$9,500,000.

Resuming:

1977/78 41,000 tons of P_2O_5 in DAP or 43,000 tons in phosphoric acid are needed. A 75,000 tons a year plant would then be producing at 57% capacity. When run for 220 days capacity would be 87%. From an economical point of view its efficiency would be low. The same applies for the sulphuric acid plant.

1978/79 52,000 tons of P_2O_5 are needed, that can be produced in 230 days at full capacity or 290 days at 80% capacity.

1979/80 63,000 tons of P_2O_5 in phosphoric acid are needed which can be performed in 280 days at full capacity. Production at that level is economically attractive. <u>In any case not later than 1979/80 production should start</u>. <u>But for 1978/79 it should already be considered seriously</u>.

1980/81 77,000 tons of P_2O_5 are needed. Production can be performed in 340 days at full capacity.

1981/82 A second phosphoric acid unit of 75,000 tons a year and a new sulphuric acid plant of 225,000 ton should come on stream, as 95,000 tons of P_2O_5 are needed. One unit should work on full capacity. The new one should produce 18,000 tons in 120 days at 66% capacity. Eventually the second unit should start one year later and the missing 18,000 tons of P_2O_5 in DAP (40,000 ton) be bought and imported.

1982/83 115,000 tons of P_2O_5 in phosphoric acid are needed. Unit 1 should produce during 330 days at full capacity, whereas 40,000 tons are produced in unit 2 in 250 days at full capacity.

1983/84 140,000 tons P_2O_5 are needed. Both units should be on stream during 330 days at 93%

<u>Conclusions</u>: The first production units of phosphoric acid and sulphuric acid should be in production for the season 1979/80. Therefore production should start in 1979. It must however be considered seriously to start one year earlier. The second production unit should be on stream in 1981 or in 1982.

This schedule is flexible and can be adapted to any situation that presents itself. It must be kept in mind that storage capacity for phosphoric acid is needed both for diluted acid (30% P2O5) which is an intermediate and for concentrated acid (50-52% P2O5). Four rubber lined tanks, each of 1600 m^3 will be needed. When the output is growing the production should be organised in such a way that activities cover a complete year, namely 330 days + 30 days for general overhaul activities. In such a way the maximum benefit is obtained from investments. Moreover a factory that is not in use, suffers more from corrosive wear than a functioning plant. This is true unless careful attendance is given during the whole period of idleness. It must however be kept in mind that the infrastructure as to storage facilities in the country and its accessibility by road must be such that transportation of fertilizer is possible all the year round. This situation should be realised at least by 1979/1980.

The availability of phosphoric acid opens the possibility to produce triple superphosphate and mono-ammonium phosphate. These products may be of importance as such or as intermediates for compound fertilizers.

Some manufacturers of phosphoric acid plants follow:-
Dihydrate plants:
Pechiney - St. Gobain, France
Etabl. Prayon, Belgium
Lurgi, W/Germany
Chemie Bau, W/Germany

Hemihydrate plants:
Nissan, Japan
Fisons, U.K.

Some manufacturers of sulphuric acid plants follow:-
Lurgi, W/Germany
Chemie Bau, W/Germany
Simon Carves, U. K.

V- 5.3.1. A sulphuric acid plant is in need of cooling water as is a phosphoric acid plant. A pumping station pumping seawater for these purposes and a discharge line for spent water has to be provided for. Moreover sweet water is needed for process purposes and as boiler-feed for the waste heat boiler in the sulphuric acid plant.

V- 5.4. Raw materials needed for the production of phosphoric acid are phosphate rock and sulphur. There are indications that both minerals are present in Ethiopian soil, but not much is known as to quantities and possibility of mining. The Ministry of Mines is highly interested to explore these deposits. But until more is known about this subject these raw materials should be imported. Phosphate is readily available from N-African deposits (Morocco, Algeria, Tunesia) and from Jordan. Opening of the Suez Canal will bring these areas within short reach from Ethiopia. Sulphur is obtained as a byproduct from oil and natural gas processing in the Persian Gulf area.

V- 5.5.1. The quantities to be imported (x1000 ton) are:-

TABLE V-2

Year	Rock-phosphate	Sulphur	Urea	Total	unloading days at rates of		
					80 t/hr	120 t/hr	240 t/hr
1978/79	170	50	49	269	154	102	51
1979/80	204	60	60	324	185	123	62
1980/81	252	74	72	398	228	152	76
1981/82	306	90	88	484	277	185	93
1982/83	374	110	107	591	338	238	119
1983/84	449	132	130	711	406	270	135

The quantities are approximate ones; the amount of rock phosphate to be used depends on its P_2O_5 content.

V- 5.5.2. The time necessary to unload these quantities are as well indicated in table V-2. A rate of 80 t/hr corresponds to unloading using the ship's gear. A rate of 120 t/hr or more corresponds to the use of harbour cranes. At present only the facilities of Assab-Harbour are available. As this port has no harbour cranes the times needed for unloading at a rate of 80 t/hr apply to the present situation. Elsewhere in this report the problems of transportation from Assab-Harbour to the factory has been treated (see chapter VI). It was calculated that a fleet of 7 (8) tipping trucks and 21 drivers is necessary to transport the discharged material to the factory if unloading is done at a rate of 80 tons/hr. Costs for unloading plus transportation are Ƀ1.67 and Ƀ2.17/ton respectively at volumes of 200,000 and 100,000 tons.

If harbour cranes installed at Assab the capacity can be raised to 160 tons/hr or more and accordingly at least a fleet of 16 trucks (48 drivers) is needed. This is only true if two ships do not arrive at the same time . A 10,000 tons ship occupies are quai for 3½ or 6½ days at unloading rates of respectively 160 or 80 t/hr (including mooring, sailing out and other activities). The present capacity is 80 t/hr or 6½ days for a ship of 10,000 ton. The unloading season is 250 days. Planning has to be such that never 2 ships are in Assab-Harbour simultaneously. This implies that about 75% or 188 days are available as a maximum. Therefore maximum unloading capacity is 29 ships of 10,000 tons or 290,000 tons. When volumes of imported materials increase large numbers of ships have to be handled. In 1981/82 this volume shall be 484,000 tons increasing to 711,000 tons in 1983/84. This implies that 2 or sometimes 3 ships are to be handled simultaneously. To handle such large volumes of materials occasionally 24 tipper trucks (72 drivers) or more are needed. It should be studied carefully whether it might be necessary to build a raw material storage at the harbour site in order to spread out peaks in arrivals of materials at the factory.

V- 5.5.3. Alternative to unloading at the port-site is to unload on a jetty in the immediate vicinity of the factory. This jetty should be equipped with one or two harbour-cranes to enable a rate of at least 120 tons/hr per crane. Transportation to the factory storage should be done using a belt conveyor, thus eliminating the use of trucks. The costs for such a jetty is estimated to be $5,830,800.- Preferably this jetty should be available by 1978 when importation of raw materials for the production of phosphoric acid and DAP starts. In this case the liquid ammonia storage can be built at the factory site and neither a secondary storage nor a pipeline with pumping facilities are needed.

A liquid ammonia storage is very expensive (see Chap. V-4.1) and can't be moved to another site. Therefore it is strongly advised to build such a storage at the factory site. A future production of ammonia asks for such a storage next to the production unit.

V- 6. Phase IV Production of Ammonia and Urea

The best raw material for the production of ammonia is natural gas. This product is discovered in Ethiopia but at present little is known about both quantities and quality. A production of ammonia has important consequences. First of all imports of nitrogenous fertilizers and of ammonia can be stopped and eventually export of nitrogenous fertilizers might be possible. Costs of ammonia production shows a sharp drop when daily capacity is 500 tons or more. At these high capacities turbine driven centrifugal compressors can be used to compress the synthesis-gas instead of reciprocating compressors. The consequences are important savings in investments costs and lower running costs.

As a comparison data from Fertilizer Industry, UNIDO Monograph No.6, 1969 are mentioned. Cost prices per ton of ammonia using natural gas as raw material are for daily capacities of 200 ton = US$27.80; 400 ton = US$22.64; 600 ton = US$17.51; 1000 ton = US$15.90.

Although these figures at present are no longer valid, their relative meaning can be accepted. Consumption in 1983/84 amounts to 112,000 tons or 360 tons/day. This means that, at the present level of technology a modern plant as described above has a too large capacity. Such a large plant therefore is only feasible when part of its production can be exported either as liquid ammonia or better as urea. Whether this is possible should be studied in detail taking into account prices of raw materials, shipping costs, investments costs etc.

V- 6.1. It must be kept in mind that production of ammonia yields carbon dioxide which is apart from ammonia the raw material for the production of urea. As a consequence urea production from imported ammonia in general is not economically attractive.

Apart from natural gas as raw material for the production of ammonia other products such as lignite, coal, fuel oil, naphta and (liquified) petroleum gas can be used. Cost prices and costs of investments are highest when using lignite, coal, fuel oil and naphta investments for a 1000 tons a day plant, respectively are 40, 39, 30 and 25 millions US, (Second Interregional Fertilizer Symposium Kiev/ New Delhi. 1971). The investments costs of a natural gas and a naphta based ammonia plant of 200,000 tons per year. (600 t/day) are mentioned (Fertilizer Manual 1967) to be respectively 13.6 and 17.7 million US dollars; production costs are respectively \$21.35 and \$46.12. This is due mainly to prices of raw materials and of energy. Conclusion is that probably only an ammonia plant of high capacity based on the use of natural gas is feasible. In this case export of nitrogenous fertilizer or ammonia is necessary.

The problem is very complicated and many important factors are liable to change within the years to come. If at some time natural gas becomes available in Ethiopia, the problem should be studied in depth.

Some manufacturers of ammonia plants:-

Kellogg Co. - USA
Chemico - USA
Montedison - Italy

Some manufacturer of urea plants:-

Chemico - USA
Toya-Koatsu - Japan
Stamicarbon - Holland
Lonza - Switzerland
Montedison - Italy

Phase V

V-7. Production of compound fertilizers

As soon as a level of 120,000 to 150,000 tons of mixed fertilizers is reached it should be considered whether a production of compound fertilizers shall replace the production of bulk blended fertilizers (Phase I).

The main difference between bulk blended fertilizers and compounds is that granules of the latter type all have the same analysis, whereas the bulk blended fertilizers have granules of different analysis. The advantage of bulk blending is its great flexibility. Compounding on the other hand entails lower costs. Therefore at a high level of consumption compounding process should be considered. There are several types of compounding processes. The two most important namely nitrophosphate processes and ammoniation processes will be discussed.

V-7.1. In the nitrophosphate processes rock-phosphate is digested with nitric acid. The obtained acidic slurry contains calcium nitrate, a highly hygroscopic product, which should either be removed (by crystalliation at low temperature) or should be chemically converted by adding sulphuric acid, phosphoric acid and ammonia. The latter process has many advantages as compared with the first mentioned because no calciumnitrate is obtained as a byproduct. Calciumnitrate is mainly used as a fertilizer in cold climates. It has no use in the Ethiopian situation.

Nitrophosphate processes have the advantage of using only small amounts of sulphuric acid and phosphoric acid. Digestion with nitric acid has a double effect, first it produces soluble phosphates, second the nitric acid itself has fertilizer value. This means a saving on sulphur which is necessary to produce sulphuric acid and phosphoric acid. Therefore nitrophosphate processes are relatively cheap. When adding potassium salts NPK fertilizer can be produced. A separate storage for compound fertilizers should be built.

This type of digestion asks for a nitric acid factory. Ammonia is the raw material, that is oxidized to nitric oxides and absorbed in water to form nitric acid of about 56%. It is obvious that the ammonia used to produce nitric acid can be either imported or produced at the factory site. For 150,000 ton/year of compounds about 50,000 ton/year of nitric acid calculated as 100% is needed. A nitric acid factory of 50,000 ton/year capacity consumes 14,500 ton of ammonia. Investment costs (1973) will be about E$6,500,000, storage of nitric acid (in stainless steel) is included. A nitrophosphate factory of 160,000 ton capacity is described in Fertilizer Manual P.152. Its costs (1967) are mentioned to be E$3,100,000. A nitric acid factory emits gases that might be detrimental to the environment.

V- 7.2. The other type of compound fertilizer production namely the ammoniation process resembles the diammonium **phosphate** process. In this type of compounding mixtures of phosphoric acid, sulphuric acid and nitric acid are treated with ammonia. Ready made DAP, TSP and ammonium nitrate could be added, thus raising plant capacity. If NPK fertilizers are wanted potassium salts have to be added. Such a plant is very flexible. Its general layout resembles a DAP plant but is more complicated. Prices will be 20-30% higher as compared with a DAP plant. A plant of 120,000 ton capacity on a 330 days/year basis (360 t/day) recently (1974) was built in W/Europe for E$5,300,000. A separate storage should be provided for.

V- 7.3. When a compounding plant is on stream the production in the bulk blending plant can be stopped as bulk blending is a more expensive production. However, the bulk blending eventually could be used for small amounts of specific mixtures. In this case the flexibility and the speed and ease with which a bulk blending plant can be operated for different blends are unrivalled advantages of such a plant.

V- 7.4. Nitric acid apart from an agent in the production of nitrophosphate fertilizers is an important raw material for the production of ammonium nitrate. Ammonium nitrate is widely used as a fertilizer in many countries, mainly as a mixture with finally ground limestone (marl) or dolomite. The mixture with limestone is known as calcium ammonium nitrate or CAN. Moreover ammonium nitrate can be used in compound fertilizers (see Chap V-7.2) Another use for ammonium nitrate is as a component for explosives. These explosives are mainly used in civil and mining activities as road building, mining operations and quarries.

V- 8. <u>Phase VI</u>

<u>Production of potassium chloride from Ethiopian deposits</u>.

At what level such a production can be economically feasible has to be studied in depth by mining experts and technologists. Production most probably should be done at the mining site. The Assab fertilizer factory therefore should not play an important role in potash production. As a consumer the fertilizer factory only will be of importance when potassium consumption in Ethiopia reaches an important level. Presently such a high level cannot be foreseen.

V- 9. <u>Summary</u>

The use of fertilizer in Ethiopia is expected to grow considerably in the years to come. This implies that when consumption grows beyond certain limits it becomes profitable to produce within the country products that now are imported. The height of these levels depend on economical factors as raw material prices and freight costs as well as on technologies. Successive phases are :-

V- 9.1. Phase I.

A bulk blending unit and bagging unit.

Such a plant is feasible from a yearly volume of 85,000 tons on. This situation is reached in 1975/76. One year later the plant can be on stream, volume is then 105,000 tons.

V- 9.2. Phase II.

At a level of 60,000 tons DAP production from imported liquid ammonia and phosphoric acid is feasible. This level is reached in 1975/76.

V- 9.3. Phase III.

Production of DAP from imported ammonia and locally produced phosphoric acid is feasible at a yearly demand of DAP of 100,000 tons or more. This level is reached in 1978/79. For the production of phosphoric acid it is necessary to use sulphuric acid to be made out of local or imported sulphur. Phase III includes the need of a pumping station for cooling water.

Phase II should be passed over because: 1st it cannot be implemented in time, 2nd because transportation of phosphoric acid is cumbersome.

Phase III should be implemented at the end of 1978 and certainly not later than 1979. Comprehensive studies should start soon. Studies should include the construction of a factory-jetty.

V- 9.4. Phase IV.

Production of ammonia and urea.

An economical production of ammonia and of urea is possible at a level of 200,000 tons N/year or more and preferably from (local) natural gas. In 1983/84 local consumption will be 112,000 tons of N. This implies the need of export of nitrogen containing products. The problems of ammonia production should be studied if more is known about the natural gas deposits in Ethiopia.

V- 9.5. Phase V.

Production of compound fertilizers.

The production of compound fertilizer can be of economical importance at levels of 120,000 to 150,000 tons. A level of 140,000 tons is projected in 1980/81. Several methods to produce compounds do exist. One of them, the nitro-phosphate process, implies the use of nitric acid to be produced from ammonia. Nitric acid can as well be used to produce ammonium nitrate and calcium ammonium nitrate (CAN). Ammonium nitrate can be used as fertilizer or fertilizer component as well as a component for explosives mainly for civil uses (road construction, mining, quarrying). This rather complicated subject asks for a detailed study in depth, in which the agricultural aspects of the use of nitrates should be included.

V- 9.6. Phase VI.

Production of potassium salts. This phase depends on the possibility of exploitation of the Ethiopian potassium deposits. The fertilizer factory will not have an important role in such a project.

V- 9.7. Production of sulphuric acid, phosphoric acid and nitric acid may give rise to air pollution. Up to what level this is to be tolerated and what measures are to be taken should be investigated.

V- 9.8. A ground plan, covering 10 Ha is added as figure V-1. The discussed units as well as utilities are presented.

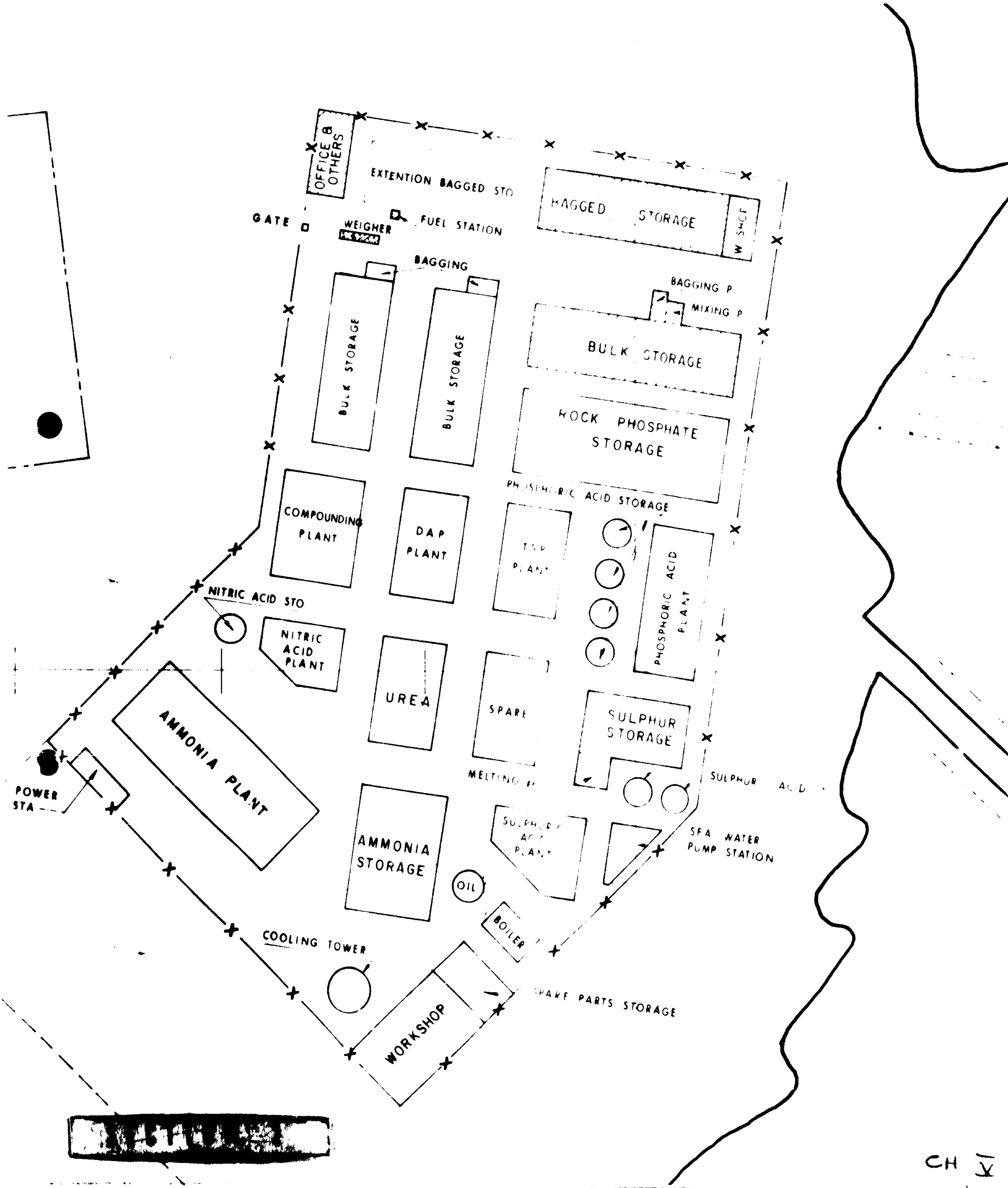
V- 10. Conclusions

1. Phase I, construction of a bulk blending plant and a bagging plant should be realised without delay.

2. The construction of a sulphuric acid plant, a phosphoric acid plant and a diamminum phosphate plant should be studied. These studies should start soon, as such a plant might be feasible in 1978/79. Import of liquid ammonia, phosphate rock and sulphur is needed. Import of phosphoric acid is not recommended. Import of urea will be continued. The construction of a factory jetty, being of great importance, should be studied without delay.

3. The local production of ammonia and urea depends on as yet unknown factors. At due time such a project should be studied.

4. The production of compound fertilizers and of nitric acid will be of importance from 1980/81 on. This is a many-sided question involving nitric acid and its derivates that could be important as fertilizers and explosives. A detailed study in depth is recommended.



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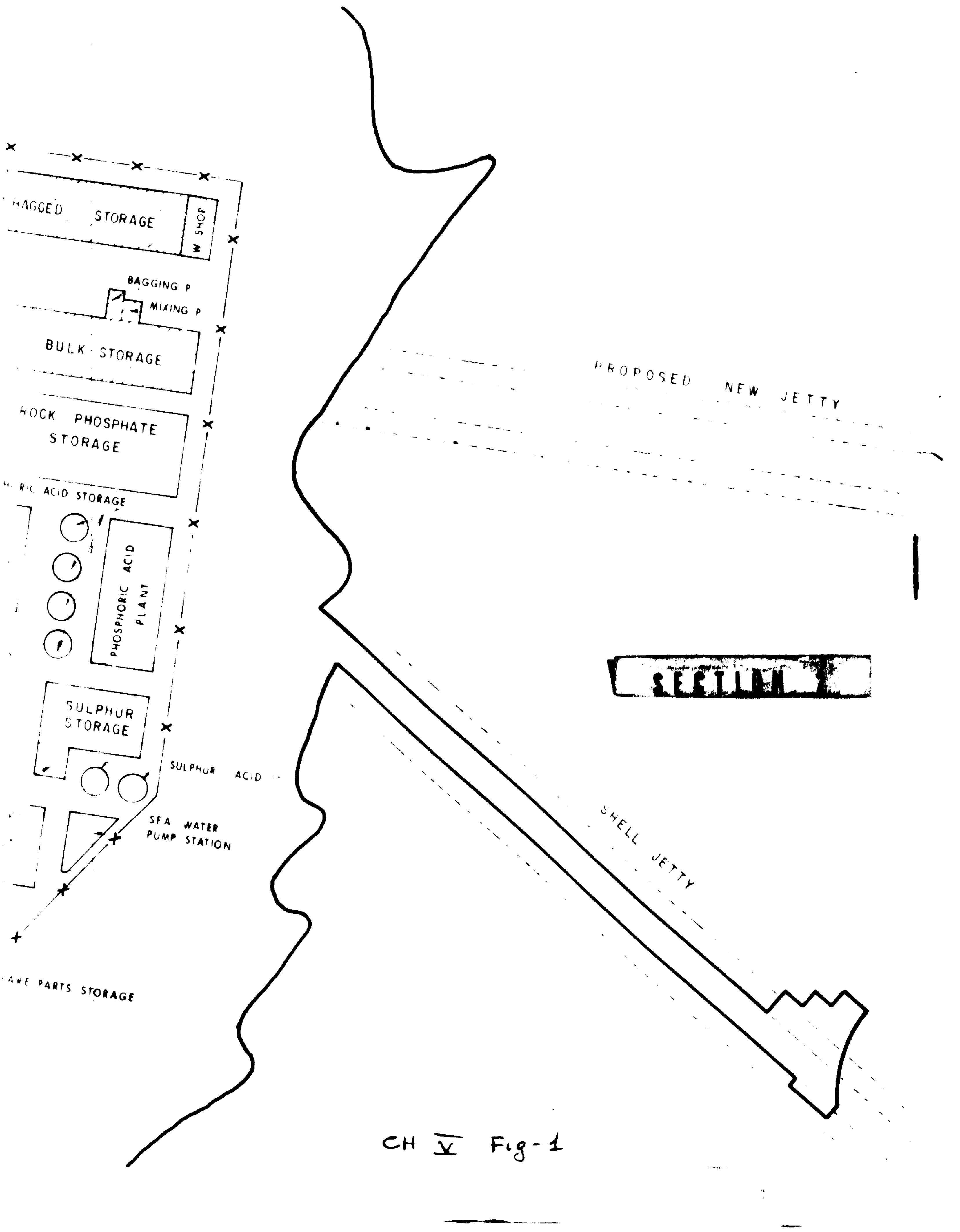
CH V



BAGGED STORAGE
W SHOP
BAGGING P
MIXING P
BULK STORAGE
ROCK PHOSPHATE STORAGE
ACID STORAGE
PHOSPHORIC ACID PLANT
SULPHUR STORAGE
SULPHUR ACID
SEA WATER PUMP STATION
PARTS STORAGE
PROPOSED NEW JETTY
SHELL JETTY

CH V Fig-1

CHAPTER VI

IMPORTATION OF FERTILIZERS AND BULK HANDLING FACILITIES

VI. General

The handling of bulk fertilizer products when arriving in sea going ships includes unloading of the ship, transportation of the materials to the factory and conveying into the storage. Two alternatives are possible in our situation. First is the use of the existing Assab-Harbour and its facilities to unload the ships and transportation to the factory over 4 km distance. Second is unloading of the ship at a jetty or quai to be constructed in the immediate neighbourhood of the factory. In this case the transportation of the unloading material to the factory will only cover a short distance. We shall consider unloading of ships and transportation to the factory in this chapter. Conveying of materials into the storage will be dealt with in chapter 7.

VI-1. Unloading of ships can be performed either by using the ships' gears or by using harbour cranes. In Assab-Harbour no harbour cranes are available. Therefore the only possibility is the use of the ship's gear consisting of winches and similar equipment. Much depends on the type of ships whether this equipment is reliable and whether its handling capacity is large or not. In many cases winches are to be operated by the ship's crew. Winches can be used with either buckets to be filled in the ship-hold by manual labour using a gang of several labourers or with a grab which asks for less manual labour. Both buckets and grabs can unload into hoppers or directly into trucks; the former method is by far superior as it affords intermediate storage Buckets have low capacities and experience has shown at Assab that a maximum 25 tons per hour or an average 20 tons per hour can be handled. (Information given by Assab Port Authorities). Grabs when used with the ship's gear should be of the "one rope" type; they can handle 40 tons per hour. It is good practice to unload two holds at the same time even when more equipment is available. No buckets, grabs, hoppers or suitable trucks are available at Assab-Harbour.

VI- 1.1. Hoppers of 10 tons capacity to receive the unloaded materials are needed. As the quais do not have a rail system stationary hoppers have to be used (prices are about $10,000). So the ship has to be shifted when another hold has to be unloaded. (10,000 tons ships currently have four holds). When working on more than two holds this would give rise to complicated situations. The use of buckets has to be rejected as capacity is low (average 20 t/hr) and large gangs are needed. Far better is the use of grabs enabling capacities of 40 tons per hour each.

VI- 1.2. <u>Harbour Portal Cranes</u> on rails. These are not available at Assab Port. Special grab cranes using "2 rope-type" grabs are the best choice. Average capacity is 120 tons per hour. They should be used with movable hoppers on rails, dimensions should be such that the portal crane can pass the hopper. Life time of cranes is very high and upto 20 years or more. Prices of cranes are $150,000 (information in Mombassa) to $375,000 (information in Holland f.o.b) excluding the rails system. Movable hoppers will cost about $40,000. Two cranes would have an average capacity of 240 tons per hour with peaks upto 300 tons.

VI- 1.3. <u>Pneumatic unloading system</u>. These systems contain a vacum system that by suction can transport materials from a ship hold to a cyclone system where the material is separated from the airstream and after passing on airlock can enter a silo. Distances between ship and silo have not to exceed 100 m. Pneumatic system have capacities comparable with those of harbour cranes with grabs. Operation is very easy. They are widely used for unloading of cereals and grains. However their use for granular fertilizers has to be discarded as excessive wear of the relatively soft granules takes place and much dust is formed. Moreover granule coatings are removed thus decreasing quality.

writer's personal experiences with pneumatic conveying of fertilizer granules were bad. As in our situation dust creates a problem, because it cannot be recycled and recoating is not possible, the use of pneumatic systems should be avoided. Prices of these conveying systems are very high.

VI- 1.4. Transportation to the factory can be performed in different ways. Some of the possible ones are trucks, belt conveyors and rope ways. The choice of the method depends largely on the length and nature of the distance to be covered.

VI- 1.5. Transportation by trucks. Trucks should be tipping types that can unload without loss of time into an underground hopper. Filling of the truck should be done using the hoppers mentioned in 6.1.1. and 6.1.2. As the capacity of tipping trucks is limited (average capacity 6 tons) a great number of trucks and drivers are needed to match the unloading activities at the quai. An advantage of a truck is that it can be used on any average road.

VI- 1.6. Belt conveyors can be used to cover small and large distances. Very simple layouts are possible when the factory is connected to a nearby jetty. Long distances can be covered up to several kilometers provided a straight line can be followed. Therefore a connection of the factory with Assab Harbour will be hardly possible as many complicated situations at the port site as well as in the town are present. However when using a factory jetty a belt conveyor fed from a movable hopper is an ideal equipment. Layout should be such that the belt conveyor is integrated with the systems of the storage building. Costs are relatively low, totaling to about $700-900 per m.

VI- 1.7. Rope-ways. In this type of equipment buckets are transported along cables. Rope-ways supported by pylons can pass obstacles in a relatively easy way, as pylons can be high and be placed at large distances. Curves can be made.

Assab-Salts Works uses a rope way of 1.5 km of length to load ships with salt in bulk. It was said that maintenance costs are very high due to excessive corrosion of the complicated equipment by the sea breeze. Investment costs are very high. The 1958 investment on Assab-Salt Works rope-way was E$2,500,000.

VI- 1.8. Conclusions

For unloading ships a pneumatic system does not offer a suitable solution. Harbour cranes are the best choice, they have large capacities; investment costs are rather high. Harbour cranes should be equippped with grabs. The use of grabs with the ship's gear is, when harbour cranes are not available, the next best choice. Buckets used with the ship's gear is not a good practice; whereas buckets in connection with cranes do not justify the purchase of an expensive crane. For transportation to the factory the best choice is transportation by truck in case materials are unloaded at Assab-Harbour. Far more attractive is the use of a conveyor belt on a jetty near the factory. Rope-ways do not give a suitable solution. Therefore as soon as possible a factory jetty with harbour cranes and a belt conveyor system chould be constructed.

VI- 2.1. Unloading at Assab Harbour. As pointed out in the foregoing paragraph, in the early years of starting the plant, all imported materials should be discharged in the Assab-Harbour. Equipment used shall consist of the ship's gear together with appropriate grabs and hoppers. Transportation to the factory is to be done by tipping trucks.

VI- 2.1.1. Since the grabs are to be used by the ship's gear they should be of the one rope type. A recent offer (Nemag, Rotterdam) for a grab of 1.8 ton capacity was D.fl 24,600 or E$19,600 f.o.b. Rotterdam.

Assuming cycles of 2, 2.4 and 3 min respectively 20, 25 and 20 cycles can be made per hour respectively representing capacities of 54, 45 and 36 tons per hour. So 40 tons per hour is a good average, corresponding to 880 tons per 22 hours. When working on two holds (see VI-1.1) the unloading capacity per day is doubled. Three grabs with one as standby are to be purchased. Total investment is $64,000 cif Assab.

VI- 2.1.2. Hoppers should be constructed on a portal and should have such dimensions that the grabs can easily unload at the top. Moreover a tipping truck must be able to pass under the portal in order to be loaded without delay. A height of about 3.80-4,00 m and a width of 2.80 m is needed to allow the truck (height 3.50 m) to pass under the portal. The hopper has the form of an inverted pyramid of basis 2.8 x 2.8 and height 2.6 plus a prismatic part of 1.50 height. Its contents are 18 m^3 or 16 tons (S.W = 0.9). On top of the hopper is a grid with square holes of 40 mm. At three sides the hopper has a platform with railing. Total height of a hopper is about 8 m. These hoppers can be transported using an automotive crane of the Port Authority. Hoppers of this kind were used by Ethiopian Amalgamated in an attempt to bag fertilizers on the quai. They might be available as they seem to be obsolete for Ethiopian Amalgamated. When manufactured in the country price will be about $10,000. Three of these hoppers are necessary.

VI- 2.1.3. Tipping trucks are needed to transport raw materials to the factory. Including the distance in the harbour area itself the total distance from ship to plant is 4 km. The trucks are loaded at the hoppers (VI-2.1.2). We were informed that tipping trucks (Mercedes) have a capacity of 6.7 m^3 or 6 tons. Assuming an average speed of 20 km per hour a roundtrip of 8 km takes 24 min. Adding 2 min for loading, 2 min for unloading and 2 min for miscellaneous activities the total time per roundtrip is 30 min. Consequently the capacity of one truck is

12 tons per hour. Unloading capacity at the quai is 80 tons/hour. This means that 7 trucks are needed to transport 80 tons. Having one truck as standby a fleet of 8 tipping trucks has to be available. Such a fleet will cost $440,000 or $480,000 including spare parts. The salvage value of the trucks after 200,000 km is assumed to be $10,000 per truck.

A fleet of 8 trucks will work 220 days a year. Planning should be such that never 2 ships are in the harbour at the same time. Then about 165 days(75%) are available to unload ships. This corresponds to 290,000 tons per year, which has to be considered as the maximum volume that can be handled.

VI- 2.2. Operating costs of unloading ships. At the Harbour site the ship's gear is used with the company's grabs and hopper. Operating costs contain capital costs and maintenance of equipment as well as labour costs. Labourers are to be provided from Port Authority and are not on the company's paylist. Wages are averaged for day and night shifts: The rate is

Foreman = $1.63/hr
Clerk = $1.75/hr
Labourer = $1.33/hr

Labour requirement per hold is shown below:-
a) In the hold + winch operator = 4
b) Hopper = 2

To supervise both holds a clerk and a foreman are needed. The winch operator might be from the ships'crew.

So total labour costs are:-

12 at $1.33	=	$15.96/hour
1 at $1.63	=	1.63 "
1 at $1.75	=	1.75 "
	Total	$19.34/hour or
		$464.16 per day (24 hr)

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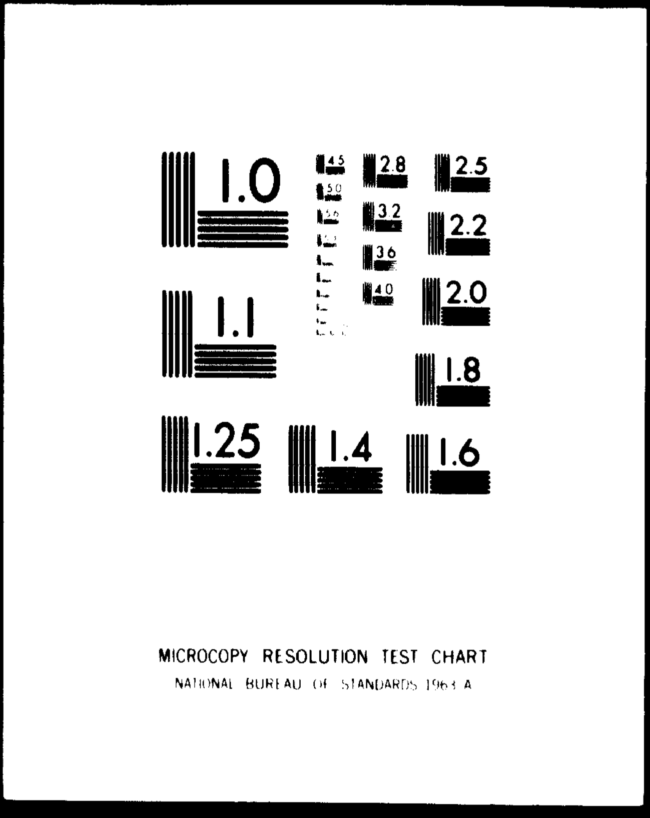

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Capacity is 1760 tons per day, so the wages component in unloading costs is $0.264 per ton.

Investments are:	3 grabs at E$19,600 fob	=	58,800
	freight	=	5,200
	3 hoppers each $10,000	=	30,000
			$94,000
	contingencies 10%		9,500
			$103,500

Yearly fixed costs are:		
Interest on capital 10%	$	10,350
Depreciation 10%		10,350
Insurance 2%		2,070
Maintenance 3%		3,150
Total fixed costs	$	25,920

Total costs for unloading

100,000 ton/year are $26,400 + $25,920 = $ 52,320 or $0.52/ton
150,000 ton/year are $39,600 + $25,920 = $ 65,520 or $0.44/ton
200,000 ton/year are $52,800 + $25,920 = $ 78,720 or $0.39/ton
290,000 ton/year are $76,560 + $25,920 = $102,480 or $0.35/ton

VI- 2.2.1. Operating costs of truck transportation. A fleet of 8 trucks (VI-2.1.3) is needed to meet the unloading rate at Assab-Harbour. For operating seven trucks on three shift basis 21 drivers are required. The rate of transportation is 80 tons per hour. On the basis of drivers wages of $300/month and inclusion of 20% idle time the breakdown of costs comes to $0.147/ton or 0.11/km for transporting 100,000 tons. It is assumed that drivers are used in the factory for other activities when no ships are to be unloaded. As a matter of fact the drivers will only be occupied on their normal duties for 1500 hr or 62 days to transport the 100,000 tons mentioned.

Other variable costs factors related to trucks are depreciation, fuel, tyres and maintenance. A truck costs $60,000 including spare parts. On the assumption of salvage value of $10,000 after 200,000 km depreciation comes to $0.25 per km. Diesel fuel consumption is calculated to cost $0.12/km; with tyres, maintenance and miscellaneous costs taken as $0.04, 0.06 and $0.03 respectively the following costs /km are arrived at:-

Driver wages	$ 0.11
Depreciation	0.25
Fuel	0.12
Maintenance	0.06
Tyres	0.04
Miscellaneous	0.03
Variable costs	$0.61/km

For the 134,000 km distance or the 100,000 ton total haulage, the variable costs stand at $81,740. Fixed costs are charged to interest on capital, insurance, wages of a truck-fleet supervisor and a mechanic in charge of repairs. Insurance and interest are calculated at 5% and 10% of the investment respectively. No allocation for road taxes is included. Depreciation and maintenance costs are included in the variable costs. Wages for supervisor and mechanic is take at $6,000 and $4,000 per year respectively. The following total results:

Interest on capital 10%	$48,000
Insurance 5% of truck costs	22,000
Wages	10,000
Total fixed cost	$ 80,000
Contingency 10%	8,000
Total fixed costs	$ 88,000

For different volumes handled corresponding costs are transportation by trucks are presented in Table VI-1.

TABLE VI- 1 Costs of transportation by truck

Imports Total traveled distance	100,000 t 134,000 km	150,000 t 201,000 km	200,000 t 268,000 km	290,000 t 389,000km
fixed costs	88,000	88,000	88,000	88,000
variable costs	81,740	122,610	163,480	237,290
Total costs	169,740	210,610	251,480	325,290
Costs per ton	$1.70	$1.40	$1.26	$1.12
Costs per km	$1.27	$1.05	$0.94	$0.84

VI- 2.2.2. Summary

Investment costs for operation outside the factory are:-

Unloading equipment:	Grabs	$ 64,000
	Hoppers	30,000
Transportation equipment		480,000
	Total	$ 574,000

Production costs vary according to the volume handled. Total costs per year for different volumes are:-

Table VI - 2

	100,000 t	150,000 t	200,000 t	290,000 t
Unloading	$52,320	$65,520	$78,720	$102,430
Transportation	169,740	210,610	251,480	325,290
	$222,060	$276,130	$330,200	$427,770

Production costs per ton for different yearly volumes are:-

	100,000 t	150,000 t	200,000 t	290,000 t
Unloading	$ 0.52	$ 0.44	$0.39	$0.35
Transportation	$ 1.70	$ 1.40	$1.26	$1.12
Total	$ 2.22	$ 1.84	$1.65	$1.47

The value of 290,000 tons has to be considered the maximum that can be handled in one season. For greater volumes the equipment for unloading and transportation has to be doubled and facilities at the factory site to receive different raw materials at the same time have to be extended.

This volume is attained when Phase III is to be implemented (1978/79) see Table VI-3

VI- 2.3. Replacement investments

The activities at Assab-Harbour will be terminated as soon as a jetty near the factory is built and becomes operational. The volumes of imported materials will rise considerably when phase III (see Chapter V-5) is operative, which is feasible from 1978/79 on. Table V-3 presents the volumes of material to be handled beyond 1975/76.

Table VI-3. volumes of materials handled (x 1000 t)

	Phase I	Phase III	Accumulated totals
1976/77	105	-	105
1977/78	126	-	231
1978/79	(160)	269	500
1979/80	(195)	324	824
1980/81	-	398	1222
1981/82	-	484	1706
1982/83	-	591	2297
1983/84	-	711	3008

Assuming that no factory jetty is constructed, then from the start up to 1979/80, 824,000 tons will have been transported, which corresponds to 1,104,000 km or 138,000 km per truck. Up to 1980/81 1,222,000 tons have been handled corresponding to 1,638,000 or 205,000 km per truck.

As the lifetime of a truck is about 175,000 to 200,000 km, the fleet of 8 tipping trucks has to be renewed after 4 to 5 years. Costs including spare parts (1974) are $480,000. Assuming that a factory jetty is operatinb by not later than 1980 renewal is not necessary.
Grabs when properly maintained have to be renewed after handling of 1,000,000 ton each. As three grabs are available, grabs have not to be renewed until 1984 when 3,000,000 tons are handled. Assuming that the factory jetty becomes operational by 1980 renewal of the grabs is not necessary. When using harbour cranes other types of grabs are needed.

The same applies to the hoppers, these items have a lifetime of 1,000,000 tons and therefore have not to be replaced befor 1984. If by that time the factory jetty becomes operational the hoppers have not to be renewed.

VI- 3.0. Unloading at factory jetty

When a jetty near the factory is constructed and is equipped with suitable equipment handling of raw materials can be performed easily. The jetty has to be equpped with 1 or 2 harbour cranes with grabs. The cranes discharge the materials into hoppers, Cranes and hoppers are movable on rails.

The hoppers discharge on a belt conveyor that is connected to the conveyor system in the storage(s). This allows high unloading rates and therefore ships can be handled in short times. This lowers costs and enlarges the capacity of the jetty.

VI- 3.1.1. Harbour Port cranes should have a movable jib and be equipped with two winches, permitting the use of grabs operated by 2 ropes. The cranes should be movable on rails; track width is about 6 m. Average capacity should be 3 tons. Operating cycle is 60-90 sec depending on shipholds etc; 80 sec being a good average. This brings the hourly capacity to 135 tons; when allowing 10% for shifting, other manoeuvering, rest etc. this results in 120 tons per hour as a good average. However under favourable conditions maximum performance of 170 tons/hr is possible. Assuming 21 hours work per day an average daily capacity of 2,500 tons results. The machine will have a capacity of 100 hp = 75 KW. Average consumption of power is about 25 KW.

In Table VI-4 the volumes to be unloaded at the jetty from 1978/79 on are presented as well as the days the factory will be operating. The days needed to unload the quantities arrived at the jetty are calculated using one or two cranes. Conclusion is that from 1982 on two cranes are necessary as 72% is a too high degree of utilisation of a jetty.

Table VI-4

Year	available days	volume in tons	one crane=2500 t/day		two cranes=5000t/d	
			days need	% of avail. days	days needed	% of avail.days
1978/79	280	269,000	108	39%	-	-
1979/80	330	324,000	130	40%	-	-
1980/81	330	398,000	160	48%	-	-
1981/82	330	484,000	194	59%	97	30%
1982/83	330	591,000	236	72%	118	36%
1983/84	330	711,000	284	95%	142	43%

VI- 3.1.2. Hoppers. Each crane should unload into a hopper that must be movable on rails. Preferably the position of the hoppers relative to the crane is such that the hopper can move under the crane's portal, this enables a position in which the crane has to slew 90° as a maximum; thus shortening the crane's cycle. The hopper should discharge on a belt conveyor through the intermediate of a feeding device. (Belt feeder or vibrating feeder). Such a hopper complete with feeder will cost about $40,000. One hopper is sufficient upto 1982.

VI- 3.1.3. Rails. Two tracks one for the cranes and one for the hoppers are needed. As driving speeds are low (20-30m per min) usually old railway-rails are used for such tracks. Ethiopian Railways informed us that these rails are sold at $0.27/kg+ taxes, that will rise the price up to $0.50/kg. Transverses cost the same price. One metre of rail weighs 10 kg as does the transverse. Rail-track for the crane is about 6 m wide, the track for the hopper is about 4.5 m. When transverses are placed at a distance of 2m; each meter of complete track costs $35.-. About 120 m of tracks are needed, total costs are $4,200; assuming construction costs to be the same and adding 20% as contingencies total costs amount to $10,030, say $10,000.

VI- 3.1.4. Grabs. The grabs to be used should be of the two-rope type. These grabs permit higher speeds of operations capacity should be 3 tons (3.5 m^3). Price is estimated to be $30,000 c.i.f. Two grabs, one as standby, are needed. A third one is needed in 1982.

VI- 3.1.5. Belt conveyor. The belt conveyor should be able to transport 120 tons per hour (with peak loads of 170 tons) up to 1982 (see Chapt. VI-3.1.1). At that time the volume to be handled demands for a second crane and capacities then rise to 240 tons/hr as an average with occasionally a peak of about 300 t/hr.

The belt conveyor covers the length of the jetty and brings materials to the storage discharging either in the base of a bucket elevator of the storage building or gradually rises to discharge on the belt conveyor in the storage (15 m). The latter construction asks for gantries to support the sloping section of the conveyor; slope as a maximum can be 15°. A bucket elevator is superfluous in that case. As in Phase III several storage buildings have to be fed by the belt conveyor a switching system should allow this.

The length of the jetty is not yet known, it will depend upon several yet unknown parameters. A length of 700 m for the belt conveyor including the junction to the storages might be a fair estimate. To transport the required quantity a belt conveyor with a speed of 1.5 m/sec and a width of 800-900 mm is needed. Costs might be $900/m. Costs of 700 m of length are to be $630,000 or $700,000 including gantries. Required power is about 90 HP=67 KW. Life time of the equipment is expected to be ten years and more. Belts have to be replaced after 2,000-3,000 days of service.

VI- 3.2.0. Summary of capital costs.

Capital costs up to 1982 are (at the basis of 1974 prices)

1 harbour crane		$ 450,000
2 grabs		66,000
1 hopper		40,000
Rails		10,000
Belt conveyor		700,000
	Total	$1,266,000
	Contingencies 15%	190,000
		1,456,000

In 1982 are to be added (at the basis of 1974 prices)

1 harbour crane	$ 450,000
1 grab	33,000
1 hopper	40,000
Total	$523,000
Contingencies 15%	79,000
	$602,000

VI- 3.2.1. <u>Operating costs</u>

Operating costs consists of energy, wages and of capital costs (interest, depreciation, insurance etc). Fixed costs are capital costs, maintenance and the wages of the crane operator ($300/month). The wages for the unloading activities are considered to be variable costs.

VI- 3.2.2. The labour needed for unloading etc consists of 1 clerk ($1.75/hr), 1 foreman ($1.63/hr) and unskilled labourers labourers ($1.33/hr) 3 in the hold, 2 at the hopper, 1 along the belt conveyor and 1 in the storage.

Totalling	7 x $1.33	=	$ 9.31
	1 x $1.63	=	1.63
	1 x $1.75	=	1.75
		Total	12.69 per hour

or $304.56 per day/24 hr) at a rate of 2,500 t/day costs per ton are $0.122.

Total power consumption is: 92 KW representing 25 KW for the crane and 67 KW for the belt conveyor. At a rate of $0.08/KWH costs per day are: 21 x 92 x 0.08= $154.56. Costs per ton at a rate of 2,500 t/day are $0.062. Total variable costs therefore stands at $0.18 per ton.

Fixed costs up to 1982 are:-

Interest 10%	$ 145,600
Depreciation 10%	145,600
Insurance 2%	29,120
Maintenance 3%	43,680
Wages crane drives (3)	10,800
Total	$374,800
Contingencies 10%	37,200
Total	411,000

Table VI-5 Costs at different volumes (one crane)

Volume	270,000 t	325,000 t	400,000 t
Fixed costs	411,000	411,000	411,000
Fixed costs/t	$1.52	$1.27	$1.03
Variable cost/t	$0.18	$0.18	$0.18
Total per ton	$1.70	$1.45	$1.21

VI- 3.2.3. Capital costs after 1982 are $1,456,000 + $602,000 = $2,058,000

Fixed costs are:

Interest 10%	$ 205,800
Depreciation 10%	205,800
Insurance 2%	41,160
Maintenance 3%	61,740
Wages crane drivers (6)	21,600
	536,100
contingencies 10%	53,900
total	$590,000

When using 2 cranes 5 more unskilled labourers will be added to variable costs as compared with the use of 1 crane. This brings total wages up to $19.34 per hour or $464.16 per day. At a rate of 5000 ton per day costs are $0.093 per ton. Energy consumption is 117 KW. At a rate of $0.08 per KWH, daily energy costs are $196.56 which corresponds with $0.039 per ton. Total variable costs are $0.13 per ton.

Table VI - 6 Costs at different volumes (two cranes)

Volume	480,000 ton	590,000 t	710,000 t
Fixed costs	$ 590,000	$ 590,000	$590,000
Fixed costs/ton	$1.23	$1.00	$0.83
Variable costs/ton	$0.13	$0.13	$0.13
Total	$1.36	$1.13	$0.96

VI- 3.2.4. Summary. In VI-2.2.2 it has been shown that unloading with the ship's gear at Assab-Harbour and transportation with trucks to the factory is limited to a volume of about 290,000 t/year. Costs are then $1.47/ton.

With one crane on the factory jetty (1978/79) a volume of 270,000 t/year has to be handled. Unit cost for this cost is $1.70/ton
Maximum performance with one crane is 400,000 t/year at a **case** $1.21/ton.

Handling costs with two cranes (1981/82) at volumes of 480,000 t/year and 710,000 t/year respectively are $1.36 and $0.96 per ton.

The conclusion is that at a volume of 270,000 tons a year (1978/79) a factory jetty with one crane from the point of view of handling costs is feasible. From 1982/83 on a second crane is feasible.

No harbour or mooring dues are considered in calculation of the above unit costs.

Replacement investments
Harbour cranes last for 15 to 20 years and therefore their replacement should not be considered before 1993 for the first crane and 1996 for the second crane. When properly maintained replacement can be 5 years later.

Hopper will last for 15 to 20 years. Considerations as to replacement are the same as those for the cranes.

Belt conveyor. The structural parts have a life time of about 15 years. The rollers should be renewed after 6 years, whereas the rubber belt will last for 4 years. Renewal costs are estimated to be $250,000 for the belt and $250,000 for the rollers.

CHAPTER VII
MIXING & BAGGING PLANT

VII- 1. Technical aspects

The mixing and bagging plant is composed of a raw material storage, a mixing plant, two bagging units and a storage for bagged products.

VII- 1.1. Storage for raw materials

The most important raw materials to be used for mixes are diammonium phosphate (DAP) and urea that permit to make mixes of ratio 1:1:0, 1:2:0; with additional potassium chloride ratio 1:1:1 can be made. From triple superphosphate (TSP) and potassium chloride a ratio 0:1:1: can be made. To arrive at suitable grades inert fillers are needed. For details on formulation see Chapter VII-2; details on specifica tions of materials including fillers are discussed in Chapter VII-1. By far the most important raw materials are DAP and urea. About 90% of the mixes to be prepared can be made out of these two products plus a filler.

The storage for raw materials should be able to contain a full shipload (10,000 ton) plus material necessary to ensure uninterrupted production. Its capacity should be 15,000 ton.

VII-1.1.1. In order to bring materials into the storage a bucket elevator conveying materials to a beltconveyor installed in the ridge of the roof is provided. The belt conveyor is equipped either with a tipping-off carriage or with a shuttle conveyor in order to discharge materials at any desired spot of the storage. The angle of repose of the materials is 30^{o}; the apparent specific weights are 0.9 - 1.0 kg/hr. Fillers are heavier.

In the period 1976 up to 1978 or 1979 transportation to the factory is done by tipping trucks with a capacity of 80 tons per hour. Up to 1981 unloading at a factory jetty is foreseen at a rate of 120 tons per hour (with peaks up to 150 tons). From 1981 on unloading rate will be increased to 240 tons per hour (with peaks up to 300 tons)(See Chapter VI-2.2).

The bucket elevator could be replaced by an inclined belt-conveyor but as the maximum angle is 15° a rather long conveyor is needed. In the first period this belt conveyor, that should be built on gantries, should have another position relative to the building as compared with the situation in which the jetty becomes operational. As it is only in 1981 that the high capacity is wanted the bucket elevator or the inclined belt conveyor could have a capacity of about 120 ton/hour whereas the belt conveyor in the storage should directly be made to meet a rate of 240 t/hr (peaks 300 t). The bucket elevator of 120 t/hr can be used later is phase III as part of the DAP or phosphoric acid plant.

VII-1.1.2. Storage building for raw material

The building is filled from the top using a conveyor belt as discussed before. The floor has to be constructed in such a way that no groundwater can rise and reach the stored products. Conditions at Assab are to be investigated and possibly a watertight floor should be constructed. Two types of buildings are studied namely those where materials are allowed to flow freely until the angle of repose is reached and those where heavy walls allow for heigher piles.

Annex 1 of this chapter contains a detailed study about the building and of the way materials should be transported to the mixing and bagging units. Results are that a building of 100 x 25 m with heavy walls of 3 m height, made out of L-shaped reinforced concrete walls and an aisle of 5 to 6 m of width along the length of the buidling enables payloaders to transport materials to the processing units. Price of the building is estimated at $486,000.

The equipment to convey materials into the storage is composed of a hopper of 12 (18) tons in which the tipping trucks (Chapter VI) unload. To ensure unloading of these trucks the hopper should either be built underground or it should be attainable through a ramp accessible for the trucks. The hopper shall unload into a bucket elevator through the intermediate of either a belt or a vibratory feeder (2HP). The elevator should have a height of 15 m and a capacity of 120 to 150 tons/hour (30 HP). As soon as the jetty is operational 1978 or 1979) this elevator is obsolete (See Chapter VI-3.1.4) however it can then be used in one of the production units of Phase III (See Chapter V-5). The elevator discharges on the belt conveyor in the ridge of the roof. This conveyor is providing with a tipping-off device and the conveyor should have a length of about 90 m. In order to be operationable after 1982 it should have a capacity of 300 t/hr; belt width should be 900 mm, speed = 1.5 m/sec. Power included tipping off device is about 15 HP. Investment costs are estimated to be $506,000 (See Chapter XI-1.2.1). Total energy = 55 KW

VII-1.1.2.1. It is not necessary that the storage building be <u>airconditioned</u>. A study carried out from meteorological data obtained through several years at Assab shows that a dangerous level of relative humidity is not reached. (See Chapter VII Annex 2). The results were that only seldom the critical humidity of urea is reached at night time in the open air. This is due to losses by radiation. In a closed storage building this situation can hardly arise. If under extreme conditions the temperature drop in the storage develops a too high humidity, some heating using an open coal fire can do away with the problem.

VII-1.1.3.1. In Annex VII-3 the problems related to the transportation with payloaders are considered. Payloaders can cover the average distance in 46 sec. Therefore one payloader has ample capacity when using buckets of 1200 or 1500 kg to transport the 80 tons per hour needed for 2 units.

Two payloaders, of which one is a standby and to be used under extreme conditions, can do the work. It has been shown that with loads of 1200 or 1500 kg and a cycle of 50 seconds a suitable programme to feed the mixing plant as well as one bagging unit can be made. (See Annex VII-4. fig $1^a 1^b$). In both schedules a hopper with four-compartments each having a volume of 7.3 m^3 or 6.6 tons is needed.

VII-1.1.3.2. Transportation by hand-carts

This type of transportation asks for a great number of carts and labourers. In Annex VII-3 this method is studied in details. The results of this study is that 25 hand carts each of a capacity of 450 kg are necessary requiring 80 labourers and two foreman for filling, transportation and discharging.

When using a manual method for transportation the hoppers of the processing units have to be built under floor level. When using wheelloaders any height of the hopper up to 2.7 m is acceptable. A high hopper has the advantage that underground construction of the hopper and the feeding device is superfluous, this diminishes costs and makes supervision easier.

VII-1.1.4. Mixing unit

The mixing unit should contain:-

i. a hopper with discharge device (2HP) cap.2.5 tons
ii. a bucket elevator (18 HP)
iii. a screen to remove lumps (2HP)
iv. a lump breaker with discharge line (10 HP)
v. a swivel spout including small hopper
vi. a four compartment hopper
vii. a batch weigher for 2-2.5 tons batches
viii. a rotatory batch mixer; cycle 2-3 min (15 HP)
ix. a discharge hopper; that is also the feed hopper for bagging unit I.
x. a suitable ventilation (8 HP) to ensure dustfree working conditions should be provided for.

More specifically the top of the bucket elevator and the casing of the screen should be ventilated. Ventilator should contain a fan plus cyclone and dust bag.

Total energy is 55 HP = 41 KW.
The layout essentially should be as described in the TVA publication "Technical and Economic Feasibility of Bulk Handling-Blending in Guatamala" February 1974, Muscle Shoals, Alabama. The output of the mixing plant should be transported without delay to a bagging unit. No storage of mixes as bulk material is foreseen.

VII-1.1.4.1. The nominal capacity of the plant as described above varies between 50 and 60 tons per hour. In actual practice 40 tons/hour will be a good average performance. The quantities of mixed fertilizers to be used in 1976/77 are projected to be 47,000 ton; in 1983/84 this quantity will be increased to 250,000 tons (See Chapter III-table 5).

47,000 ton can be produced in 168 days at a daily capacity of 280 tons and with one shift. The capacities of the mixing unit for 330 days and 1, 2 or 3 shifts respectively are 92,400, 184,800 and 277,200 tons a year.

VII-1.1.4.2. The equipment preferably should be installed in a high building. The bucket elevator brings the material to the top of the building; further transportation is done by gravity. A bucket elevator of 80 tons per hour capacity is needed to ensure ample time to transport the different components to the four compartment hopper (See Annex 4, fig 1c, 1d).

The elevator discharges on a screen that therefore should have the same capacity. The screen should have openings of 5 x 5 mm. Oversize is fed into a lumpbreaker, preferably a cage mill. Its discharge has to be recirculated to the screen. Since oversize does not exceed a few percents, a capacity of 5-10 tons/hour for the lumpbreaker is sufficient. The discharge of the screen passes through a swivel spout to a four compartment hopper. The swivel spout is operated by a labourer, who also operates a communication system to either the payloader driver or a labourer who controls the feeding of the hopper. Communication should be done using appropriate light signals. In Annex 4 the dimensions of the compartmentalized hopper are calculated. A hopper with a crossection of 2.8 x 2.8 m having a pyramidical part of 2.8 m of height and a prismatic part of the same height can hold 29.3 m^3; which is 7.3 m^3 or 6.6 ton per compartment. The 4 compartments should each have a discharge valve that can be put in positions for coarse and for dribble feed. Manual operation of these valves will be satisfactory. The operator of the weigher operates these valves. The valves discharge into a weighing hopper which has to be fitted with a bottom discharge valve. The scale must be fitted with an indicator system that enables faultless formulation of components. Movable discs each designed for a specific formula are very practical. The capacity of the weigher should be 2.5 tons. Immediately after the batch is weighed, the operator discharges it into the (emptied) mixer, that is operated by the same operator. The mixer should be of the rotary type, more specifically the type that constantly rotates in the same direction. Cycle time should be 2-3 minutes.

The mixer discharges into a holding hopper that has to contain the complete batch. This hopper, that is connected directly to the bucket elevator of the bagging plant, serves as feed hopper in case the mixing unit is not used and only straight fertilizers have to be bagged.

Ample equipment for dedusting should be provided for. The most important is the ventilation of the bucket elevator discharge and of the screen casing that is directly connected to this discharge. Investment costs for the mixing plant are $481,000 (See Chapt.XI-1.2.3)

Fig. 2,3,4. presents a flow sheet and a ground plan for the mixing unit.

Fig. 1.5. presents a layout for the raw materials storage and the processing units. One building contains both mixing and bagging plant (See Chap.VII-1.1.5.2).

VII-1.1.5. <u>Bagging plant</u>

The plant should contain two bagging units. One of them is directly connected to the mixing plant thus enabling bagging of the mixed fertilizers without delay. However in case no mixes have to be produced this unit should be able to process straight fertilizers as well. In this case the mixing plant would be idle.

The second unit is meant mainly for the bagging of straight fertilizers but could also be used for mixed fertilizers (see fig. 6).

VII-1.1.5.1. Both units should each have a maximum capacity of about 50 tons. Average will be 40 tons per hour. Each unit should contain:-

i. <u>a hopper</u> with unloading facilities (belt feeder, vibrator feeder or the like (2 HP)

ii. <u>a bucket elevator</u> of 80 tons/hr capacity (18 HP)

iii. a double deck screen in a dust free casing (including dust bin) to separate lumps and dust from on size granules (2 HP).

iv. a lumpbreaker (10 HP) fed by a screw (1 HP) conveyor from (iii) including discharge.

v. a hopper with gate valve to feed the weighers. The hopper should be fitted with level indicators.

vi. a set of (duplex) weighers with inlet spouts and control mechanism, frame and discharge funnel (2 HP)

vii. a filling spout allowing dust free operation

viii. electrical equipment for automatic control and regulation of (vi) and (vii).

ix. a slat conveyor or beltconveyor to transport the filled bags to closing equipment (3 HP)

x. a heat sealer for p.e. liner bags (7.5 KW)

xi. a sewing machine for jute, p.e. or similar woven bags (0.5 HP)

xii. ventilation units to ensure dust free operation, containing fan, cyclone and dustbag. Most important is a ventilation of the elevator discharge and the screen casing (8 HP) and a separate small unit for the filling spout (1.5 HP). The first one asks for about 1000 m^3/hr at 60 mm watergauge. The filling spout should be ventilated by a unit of a capacity of 45-60 m^3/hr. Air velocity has to be 75-100 cm on the spots were dust possibly could settle.

xiii. an air compressor for weighers and filling spout control. Capacity should allow to operate both units about 30 m^3/hr 4-6 atm are needed (15 HP). Recent quotations from W/Germany manufacturers amount E 82,000 to 89,000 fob. Europe for items (vi) to (xi) Total power requirement is 37 HP + 7.5 KW = 35 KW.

VII-1.1.5.2. The two bagging units and the mixing plant should be installed in one building made out of structural steel with corrugated asbestos sidings and roofing. A hoisting shaft for installation and removal of equipment as well as a staircase are shared by mixing and bagging units. The exact dimensions of the building depend on the equipment to be installed. The steel structure should be adapted to the equipment. Materials are conveyed to the top of the building by the bucket elevator and subsequent transportation is mainly by gravity.

Once the bags are filled transportation to sealing and sewing machines is horizontal. Part of this equipment is in a lower building. This part contains ample room for the storage of empty bags and for insertion activities to combine inner and outer bags. It is assumed that the building has a volume of 2000 m^3; its costs are $140,000. For the sake of simplicity $70,000 is imputed to each of the bagging and mixing plant.

Fig 1 to 5 present ground plan and flowsheet for a possible layout.

VII-1.1.5.3. Dust is collected from the different units. The sieves in the bagging units will produce as a maximum 1% of the throughput as fines, but currently percentages are much lower. Specifications should include that no material be caught on a 28 Tyler mesh or 0.59 mm screen. Careful handling and transportation conditions are of importance. Very small amounts of dust are produced in the ventilation units.

As a maximum 400 kg of dust can be produced per hour, but currently quantities are much smaller. These fines should be transported (by a chute-pipe) to collectors. From an agricultural point of view the fines are as good as granules but broadcasting is less convenient. They should be sold at reduced prices. Investment costs for the Bagging plant are $936,000 (See Chap.XI-1.2.4)

VII-1.1.5.4. A truck weigher to be used for incoming materials as well as for outgoing bagged fertilizers is a very useful equipment item. It enables to check in-and output. It should be placed near the entrance gates. Investments are $23,960 (see chapter XI-1.2.6.)

VII-1.1.6. Storage of bagged fertilizers

An ideal situation would be to load all bags directly after filling trucks and transport them to the inland storages. It is obvious that this is only possible in a limited way and therefore an intermediate storage has to be provided for. A storage capacity of 10,000 ton provides with the desired flexibility. Storage of bags can either be done by using pallets or piles erected by manual labour. In the latter case some specialized equipment might be helpful. In Annex 5 these methods are discussed in details and calculations of performances and costs are made. The results are a building of 65 x 40 m and a height of 5.5 to 6 m under the trusses. This includes an aisle of about 6 m for manoeuvering. The floor has to be flat to ensure safe operations of fork trucks and other equipment. Costs of such a building are $325,000. An additional outlay of 6,000 m^2 for a workshop building is expected.

VII-1.1.6.1. Forktruck transportation including loading of trucks asks for 2 forktrucks (one as standby) and 5000 wooden pallets. Workforce includes 1 driver, 1 foreman and 16 labourers. One shift can handle the production of 100,000 ton per year. It is assumed that 75,000 ton of fertilizer are handled in and out storage. Costs are: Investments of equipment = $224,000

VII-1.1.6.2. Manual labour. Wheelbarrows are used for transportation from bagging unit to storage and for transportation from storage to trucks. Piling is done entirely manual. 40 wheelbarrows are needed when 4 bags are handled in one cart. 64 labourers plus two foremen are needed. Investment costs are $2,400.

VII-1.1.6.3. Transportation by manual labour plus piling equipment The equipment required are two movable and adjustable beltconveyors allowing steep slopes to reach the top of the pile. Workforce include 37 labourers and 1 foreman. Investment costs are $60,300.

The best choice is the last mentioned alternative as investments are moderate and operation costs are low. The use of auxilary equipment offers better prospects for gentle and careful handling than entirely manual handling.

VII - 2. Operation costs. Operation costs include depreciation and maintenance, insurance costs of the buildings as well as labour and energy costs.

For buildings depreciation is 5% and maintenance costs are 1% of investments. For equipment depreciation is 10% and maintenance 3-6% depending on the nature of the equipment.

VII - 2.1. Storage of raw materials

Investments costs are:-

Building		$ 486,000
Equipment		506,000
	Total	$ 992,000

The installed power is 47 HP = 35 KW. 3 labourers are needed; two at the discharge of the tipping trucks and one to operate the tipping-off device of the belt-conveyor. The foreman dealing with transportation to the storage supervises transportation to the processing units as well. Three shifts and 1500 hours are needed to transport 100,000 ton (See Chapter VI-2.2.1) which amounts to 4,500 man hours + the activities of 3 foreman at $200/month.

Operating costs are calculated in Chapter XI-2.3. Results for different volumes handled are:-

Volume	100,000 t	150,000 t	200,000 t	290,000 t
cost per ton	$2.28	$1.57	$1.21	$0.88

VII- 2.3. <u>Transportation from storage to processing units</u>

In Annex VII-3 two different ways of transportation are discussed, namely transportation by payloaders and as an alternative by manual labour. In both cases labour is continuously used and can be considered as fixed costs.

VII-2.3.1. Results are that when using 2 payloaders of which one as standby investment costs are $168,000 and operating costs are $82,900. When a volume of 100,000 ton is handled costs are $0.83/ton. The maximum capacity to be handled by one shift in 330 days is 200,000 tons; handling costs are $0.45 per ton. (See Chapt.XI-2.4)

VII-2.3.2. When using handcarts investments costs are $58,000. 80 labourers are needed for manual transportation at a rate of 80 tons/hr. 100,000 tons can be handled in 220 days. As a maximum 200,000 ton can be handled with one shift in 330 days. Operating costs are $1.63 and $0.81 respectively at volumes of 100,000 and 200,000 ton.

Transportation by a crew of 80 labourers in the proper sequence to the processing units is a very complicated task due to the great number of units and to the different products (3-4) to be transported. A great stress is put on the foremen, who are responsible for faultless operations. As mistakes can be very costly and can harm the good reputation of the factory transportation by payloaders is by far preferable to manual transportation.

VII-2.4. Mixing operations

The mixing plant has to be operated by 3 labourers, one at the receiving hopper whose task is to survey the proper sequence of conveyed components, one at the discharge of the screen whose task is the operation of the swivel spout to the 4-compartment hopper and the attendance of the communication system. The third operator is in charge of the batch weigher and of the operation cycle of the mixer including charging and discharging. A foreman to coordinate and supervise these activities is as well in charge of the bagging operations. As these latter activities have a large volume his costs are imputed to the bagging costs. Energy costs include conveyor systems, lump crusher and mixer. Total power is 41 KW (VII-1.1.4). Investments are $481,000 to which has to be added $70,000 for the building (Chapter XI-1.2.3). Operation costs when run with one shift are calculated in Chapter XI-2.5. Results for a volume of:-

100,000 ton per year costs are $2.94 per ton
200,000 ton per year costs are $1.61 per ton

VII-2.5. Bagging operations. Each bagging unit has to be operated by one labourer at the receiving hopper, one at the filling spout, one at the heat sealer and one at the sewing machine. Moreover for both units together one labourer to survey screens and weighers and 3 for feeding the bagging units with bags and for inserting inner and outer bags. Moreover one foreman to survey both units as well as the mixing plant. Total number of labourers therefore is 12 plus one foreman with technical knowledge.

Investments (XI-1.2.4) are:
$936,300 for equipment plus $70,000 for the building (VII-1.1.5.2). Total investment is $1,006,300.

Operating costs when run
at a volume of 100,000 ton/year costs are $2.88/ton
at a volume of 200,000 ton/year costs are $1.60/ton

VII-2.6. Storage of bagged products

In Annex VII-5 details are given about transportation of bags to storage. Three alternatives are considered namely:-

A. The use of forktrucks and pallets

Investments are $224,000
Assuming 100,000 tons of bags are handled costs are $1.71 per ton; at 200,000 tons costs will be $0.85. In this case 16 labourers, 1 driver and 1 foreman are needed.

B. Use of manual labour

Investments are low: $2,400
64 labourers and 2 foremen are needed. Costs assuming 100,000 tons in and out storage are $1.79 per ton.

C. Use of manual labour plus piling equipment

Investments are $60,300
37 labourers and 1 foreman are needed.
Costs in and out storage at a volume of 100,000 tons are $1.50 per ton or $1.10 at the double capacity(2 shifts).
Conclusion is that (C) offers a good choice. Costs are low and investments are moderate. As compared with (A) it creates more employment. As compared with (B) it offers better prospects for gentle and careful handling of bags, resulting in less damage.

VII-2.7. Truck weigher

Investments costs are $23,900. (See Chapter XI-1.2.6).
It is assumed that no extra personnel is needed to operate the weigher. The gate-keeper could do this work.

Operating costs (see Chapter XI-2.8)
For 100,000 ton are $0.06 per ton
200,000 ton are $0.03 per ton

VII- 2.7. Summary

Costs for investments and operation of storage and handling of raw materials mixing and bagging units and storage and handling of bags are summarized in the following table.

Table VII-1

	Investment	Operating Costs 100,000 ton	200,000 tons
Storage in	$ 992,000	$2.28	$1.21
Storage out	168,000	0.83	0.45
Mixing plant 50% of volume	551,000	2.94	1.61
Bagging Plant	1,006,300	2.88	1.60
Storage bags	385,300	1.50	1.10
Trucks weigher	23,900	0.06	0.03
T o t a l	$3,126,500	$10.49	$6.00

VII- 3. Replacement investments

The storage building contains a bucket elevator and a belt conveyor system. Lifetime of these apparatus is 15 years or longer.Of the bucket elevator chains and drive wheels have to replaced every 4 years at a cost of $ 50,000

The buckets have to be renewed after 8 years of service at a cost of 40,000

The motor and the gear reduction have to be replaced after 10 years, costs are 9,000

The belt conveyor system has a lifetime of 15 years or better. The rollers have to be renewed after 6 years, costs are 35,000

the rubber belt after 4 years costs are 35,000

The two motors of 3 and 12 HP and their reduction gearbox have to be replaced after 10 years of service at respectively 900 &2,400

The equipment for transportation to the processing units have to be renewed after 10 years. When properly maintained the engine can attain the same lifetime. It might however be necessary to renew the engine after 5 years of service. Costs are estimated to be...........	$ 20,000
<u>In the mixing plant</u> have to be renewed: beltconveyor at the hopper after 15 years and after 4 years a belt at	1,500
rollers after 6 years at	1,500
motor after 10 years at	600
The bucket elevator has a lifetime of 15 years to be renewed are after 4 years chains etc at	22,000
buckets after 8 years at	22,000
motor + gearbox after 10 years at	5,400
The screen has a lifetime of 15 years	
Lump breaker: lifetime 10 years	10,000
The weigher has a lifetime of 10 years	10,000
The mixer has a lifetime of 15 years and longer; after 10 years motor and gearbox have to be renewed costs are	4,500
The discharge belt of the hopper has a lifetime of 15 years. To be renewed are:-after 4 years belt at	2,400
<u>In the bagging plant</u> have to be renewed 2 bucket elevators after 15 years, intermediate renewals like chains etc. after 4 years at	40,000
buckets after 8 years at	40,000
motor after 10 years etc. at	10,800
The feeding belt has a lifetime of 15 years, but to be renewed are after 4 years a belt at	1,500
after 6 years rollers at	1,500
after 10 years motor etc. at	600

STORAGE BUILDING FOR RAW MATERIALS

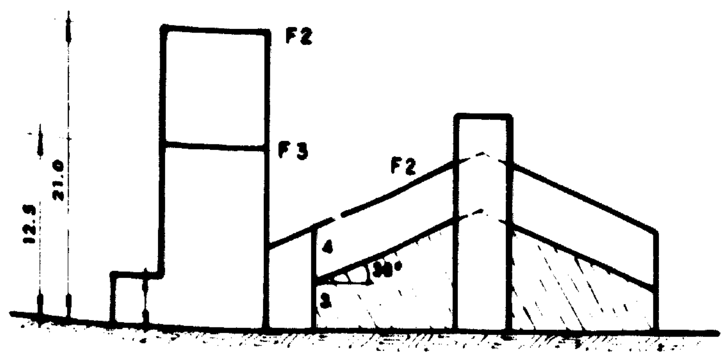


FIG 5b

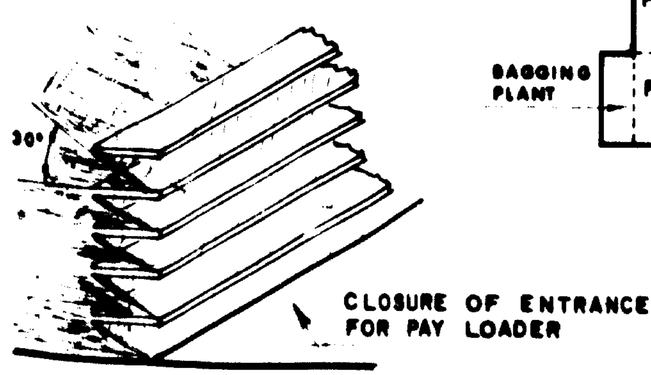


FIG 5c

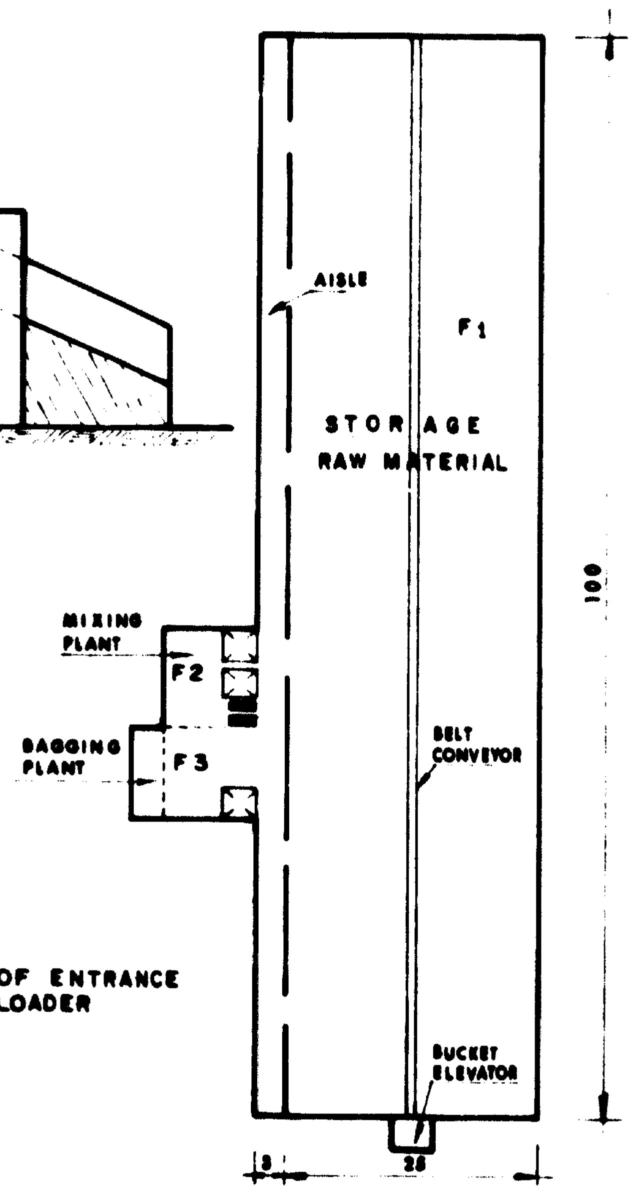


FIG 5a

FIG 5

[redacted]

CH

TORAGE BUILDING FOR RAW MATERIALS

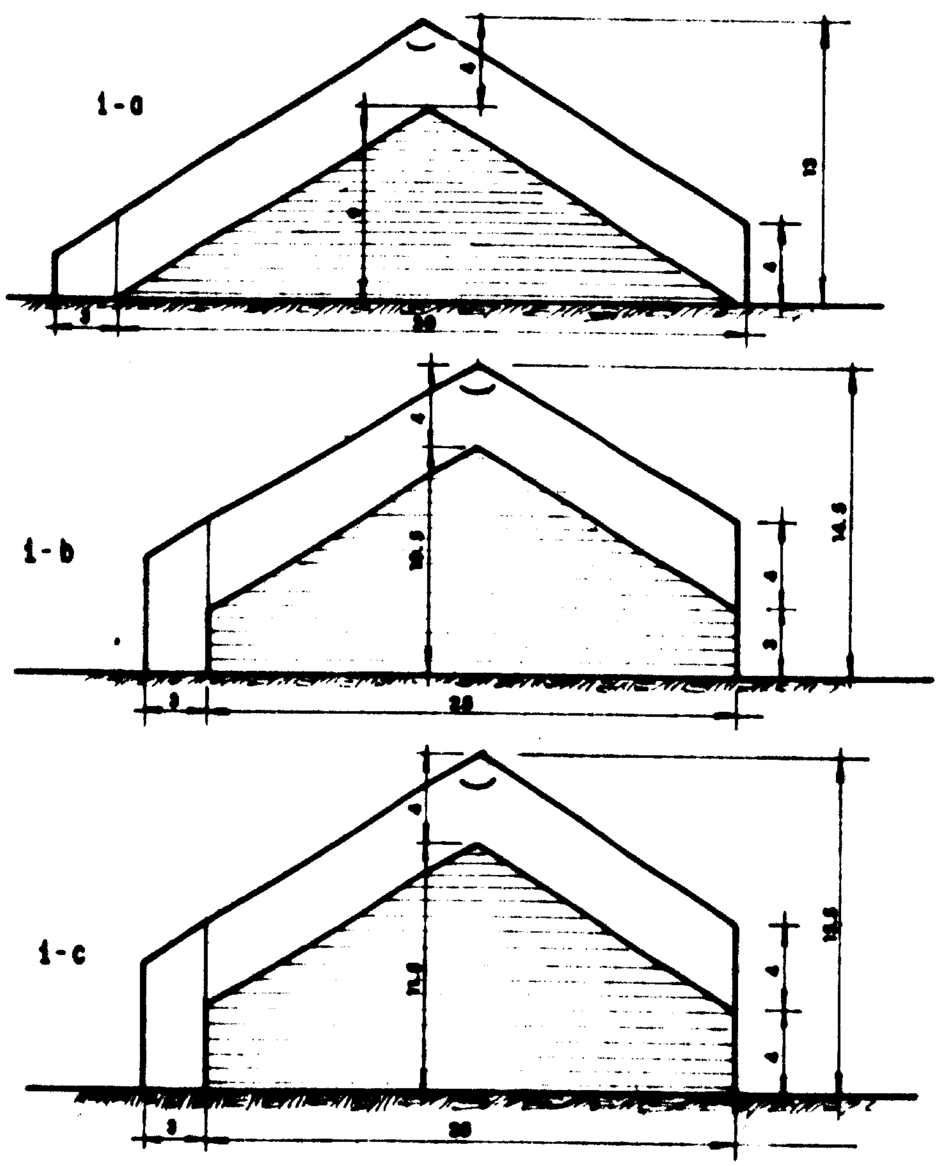
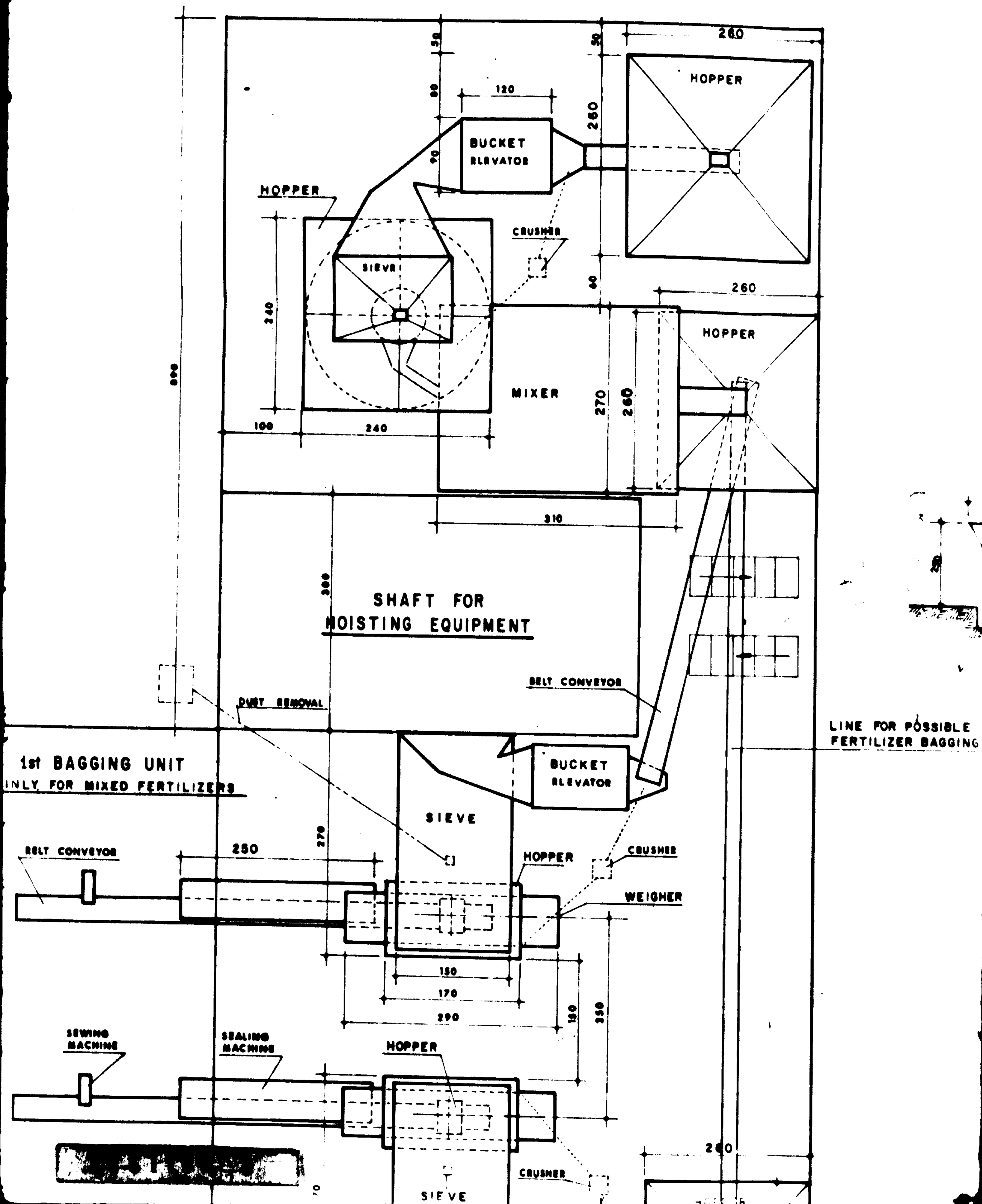


FIG 1

CH VII Fig 1



HOPPER
BUCKET ELEVATOR
HOPPER
SIEVE
CRUSHER
HOPPER
MIXER
SHAFT FOR HOISTING EQUIPMENT
BELT CONVEYOR
DUST REMOVAL
LINE FOR POSSIBLE FERTILIZER BAGGING
1st BAGGING UNIT
ONLY FOR MIXED FERTILIZERS
BUCKET ELEVATOR
SIEVE
HOPPER
CRUSHER
WEIGHER
BELT CONVEYOR
SEWING MACHINE
SEALING MACHINE
HOPPER
CRUSHER
SIEVE
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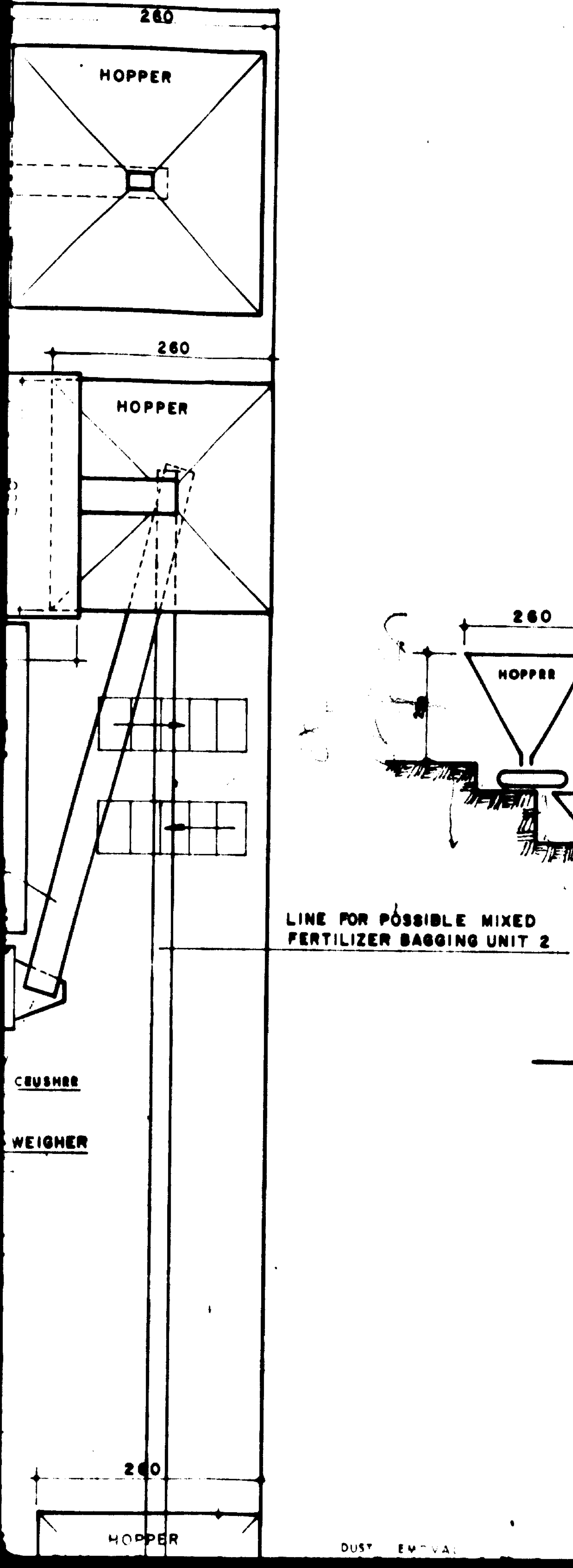
170
290
150
250
260



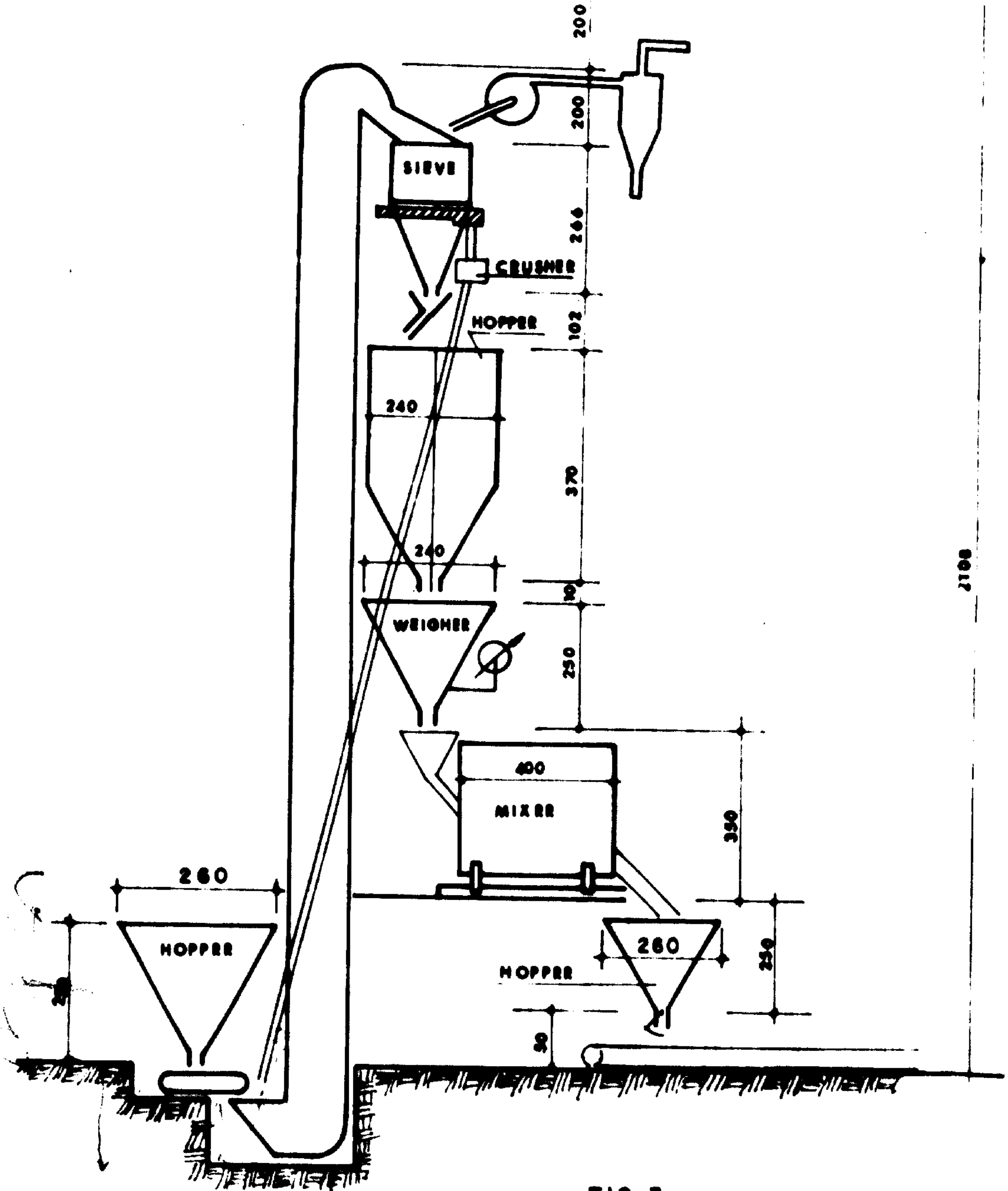
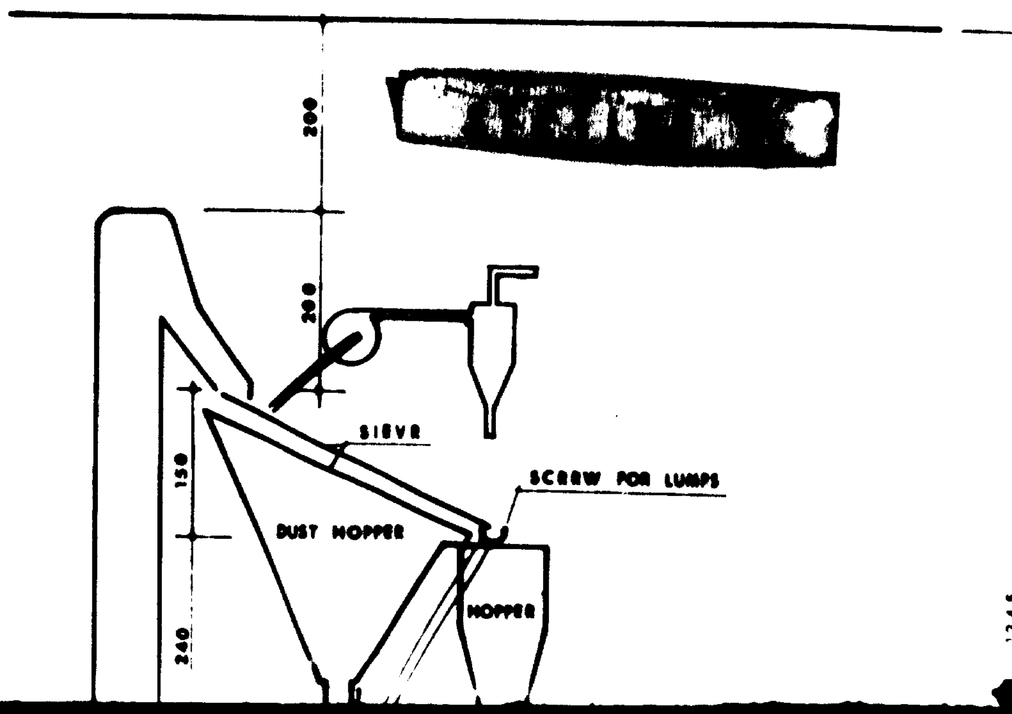


FIG 3

MIXING PLANT ELEVATION FLOW SHEET



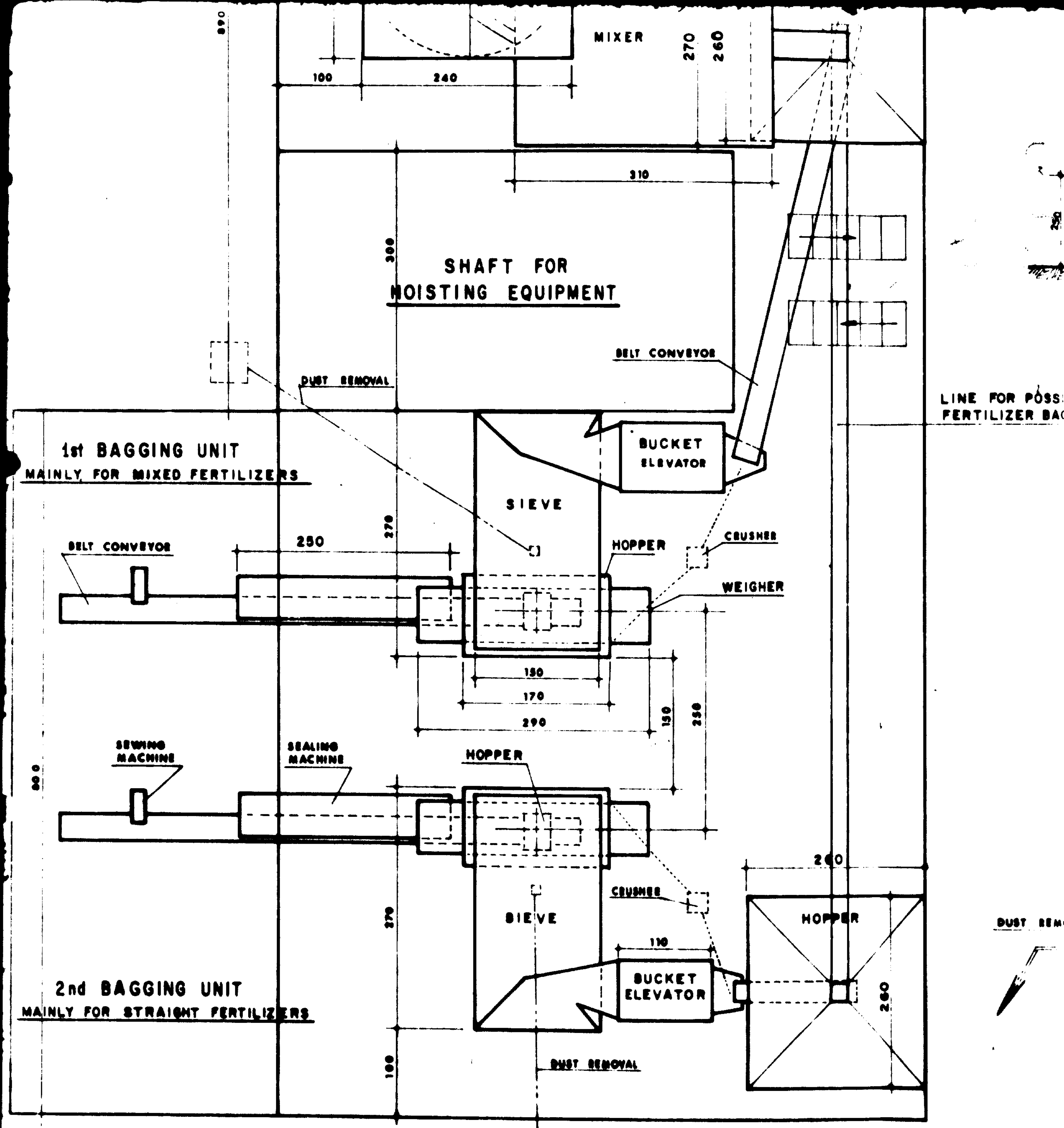
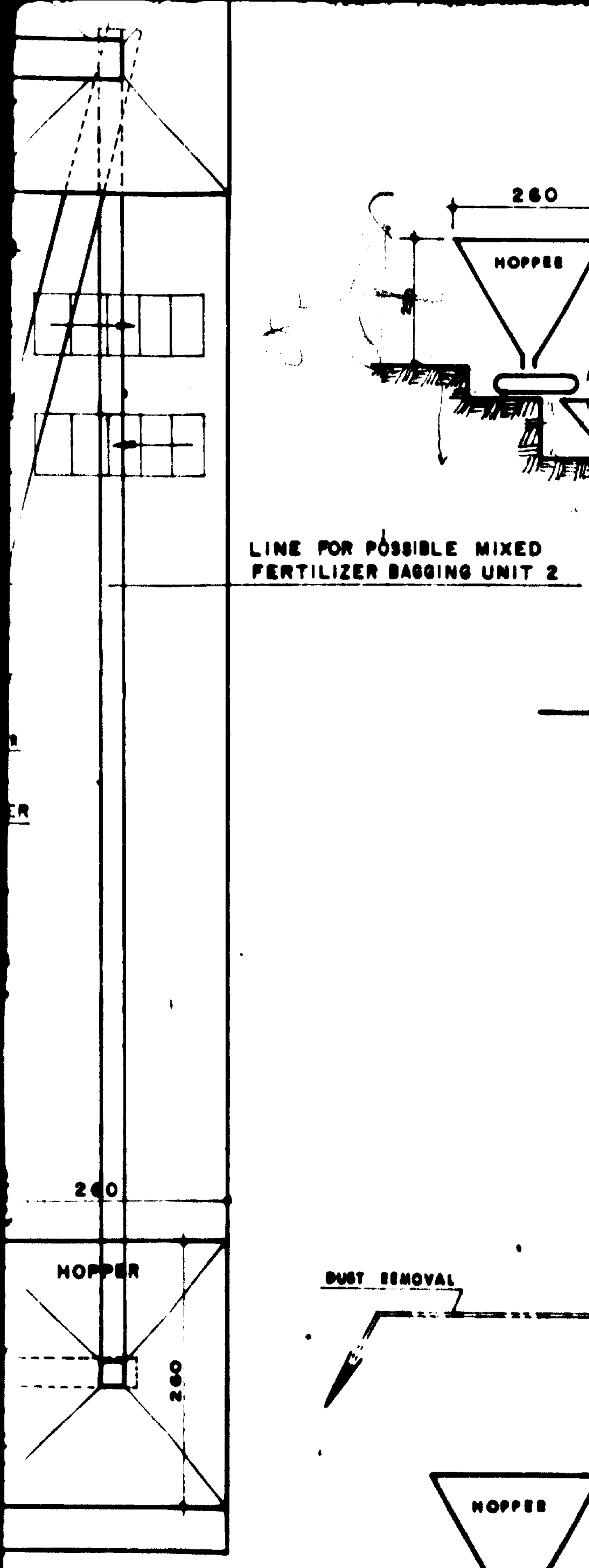


FIG 2
GROUND PLAN FOR
MIXING AND BAGGING
PLANT

ch VII Fig -2



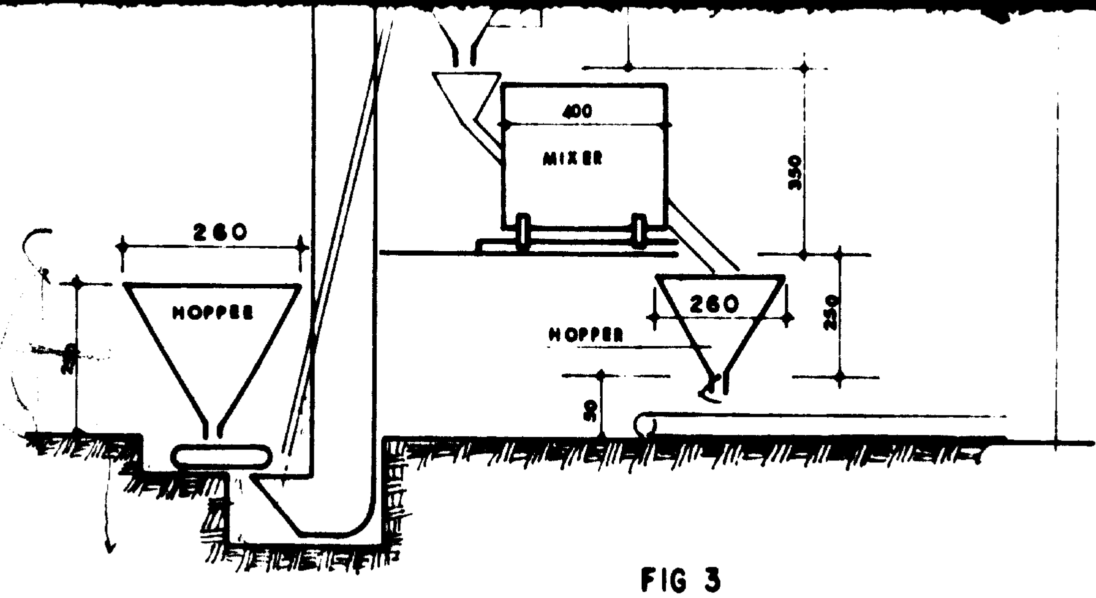


FIG 3

MIXING PLANT ELEVATION FLOW SHEET

SECTION 4

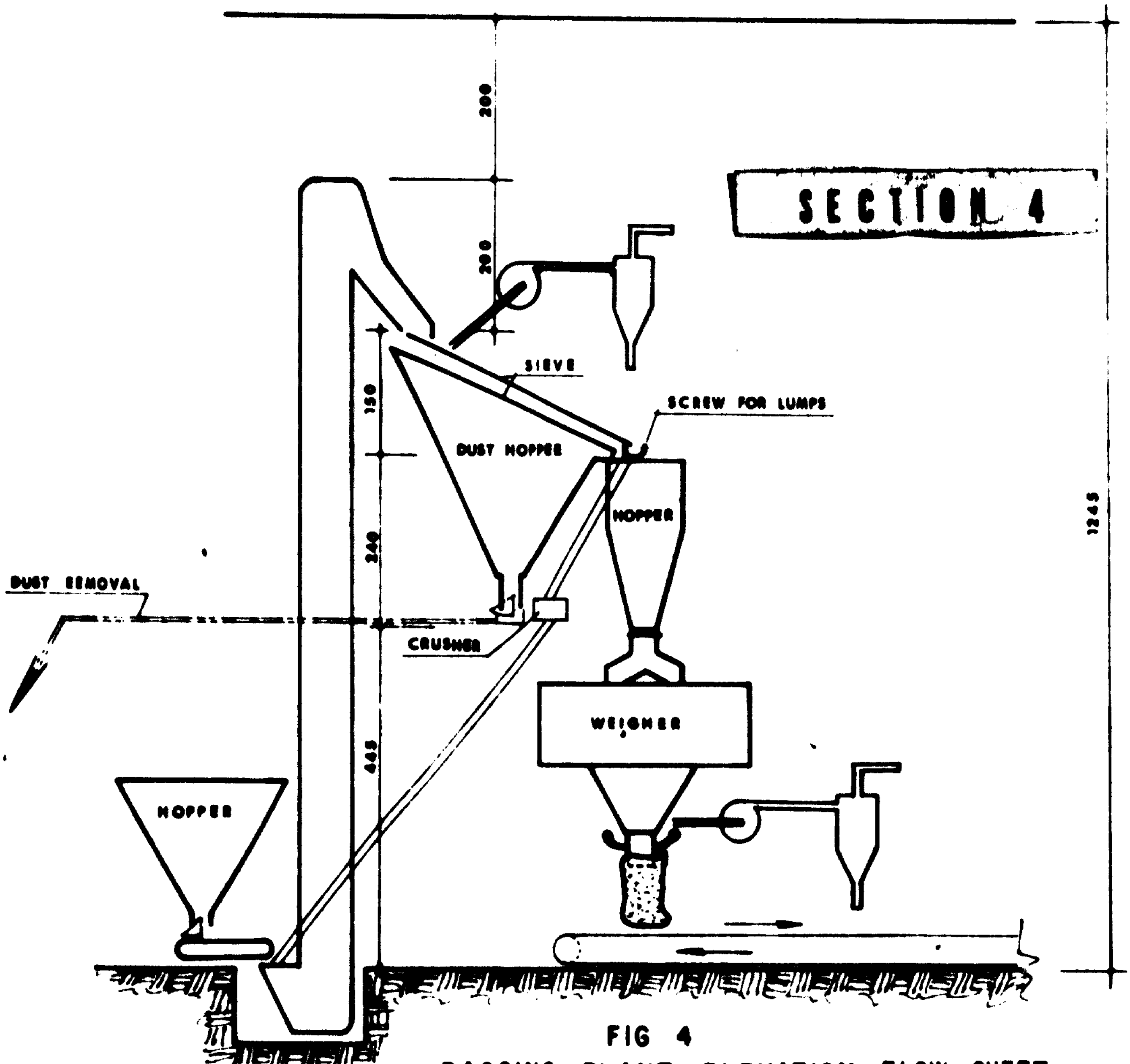
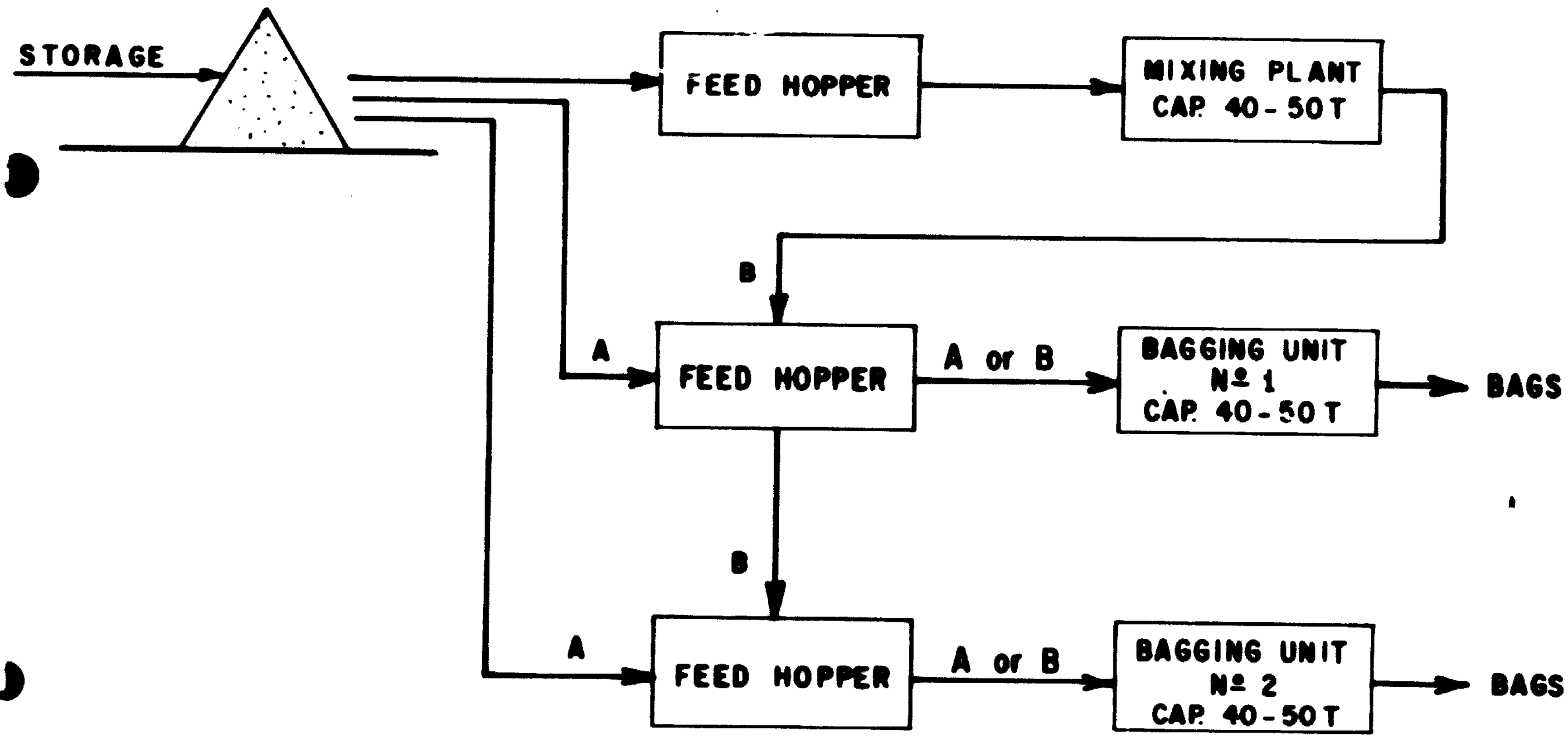


FIG 4

BAGGING PLANT ELEVATION FLOW SHEET

ch VII Fig -2



NOTE:

A = STRAIGHT FERTILIZER

B = MIXED FERTILIZER

Ch VII Fig-3

The screen has a lifetime of 15 years. The lumpbreakers have a lifetime of 10 years costs are	$20,000
The weighers have a lifetime of over 10 years the slat conveyors have a lifetime of 15 years, its belt and rollers have to be renewed after 4 years at a cost of	5,000
respectively, after 6 years at a cost of	5,000
The heatsealers have a lifetime of 10 years their costs are	50,000
The sewing machines have to be renewed after 10 years at a cost of	16,000

<u>In the storage of bagged products</u> renewals are:

after 4 years 40 wheelbarrow at a cost of	2,400
The conveyors for piling bags have a lifetime of 15 years, but after 4 years the belts have to be renewed at a cost of	15,000
after 6 years the rollers at a cost of	15,000

<u>The lifetime of the truck weigher</u> is 15 years or better.

Chapter VII Annex I
Storage of raw materials

1. In the chapter on mixing and bagging plant (see fig 1) three types of storage buildings were mentioned, each to contain 15,000 tons. In these buildings the raw materials are filled from the top of the building using a conveyor belt with a tipping-off carriage or a similar device.

The floor of the storage has to be constructed in such a way that no ground-water can rise and reach the stored products. It has to be investigated what the conditions are at the Assab-site and possibly a watertight floor construction should be provided for.

1.1. A. Building without heavy walls (fig Ann.1-a)
As there are no heavy walls, the material flows freely to reach the floor at the angle of repose of 30°. Assuming an apparent specific weight of 0.9 a volume of 16,700 m^3 is needed. A building of 125 m of length, a width of 30 m and a height of 4 m above the top of the pile has a total volume of 31870 m^3 and a surface of 3750 m^2. Total height is 13 m. An aisle for the payloader should be provided for, in order to enable a trouble free transportation this aisle should have a width of 5m. Its surface therefore is 625 m^2, which brings the total surface upto 4375 m^2. The aisle and the storage building should be separated by a wall preventing dust to penetrate into the aisle. In this wall apertures of about 3-4 m of width should be provided for to enable the payloaders to enter the storage. Sidings and roofing of the storage building should be made of corrugated asbestos cement.

1.2. B. Building as a with heavy walls of 3 m height enable to withstand the pressure of the material. These walls could be made either out of masonry (B-1) or out of I-shaped reinforced concrete wall sections (B-2). (See Fig Ann 1-2). Ato Abebe Muluneh made calculations as to costs and dimensions. In order to contain the raw materials a building having a length of 100 m and a storage width of 25 m can contain 15,000 tons. Total height is 14.5 m assuming a free space of 4 m above the top of the pile.

1.2.1. B-1. The heavy walls made out of masonry were calculated to have a thickness at the basis of 2.10 m, at the top of 0.50 m. Average thickness is 1.30 m. So the building has to have an overall length of 100+ 2x1.30 m or about 103 m and an overall width of 25 + 2 x 1.30 or about m in order to have an average useful surface of 2500 m^2. The cost of such a masonry wall is calculated to be $243.40 per m of length. An aisle of 5 m should be provided for, which brings the overal width of the building upto 33 m. The aisle should be separated from the storage. Total surface is 3400 m^2. The heavy walls should have at regular intervals openings of 3-4 m of width in order to enable payloaders to enter the storage. This apertures should be closed by light wooden constructions. In fig 5-c such a construction is presented. When the angle of repose is taken into consideration construction can be such that there is no lateral pressure on the closure.

1.2.2. B-II. Instead of masonry walls L-shaped structures made out of reinforced concrete are used to retain the pressure of the stored material. These structures have an average thickness of 11 cm; in our calculations as to the dimensions of the building this dimension can be neglected. The separate units have a width of 0.92 m; they should be put one next to another. Wooden beams bolted to the separate units hold them together. The price is calculated to be $370 per m of length. The building has as dimensions: length 100 m, width 25 m, aisle 5 m, so total width - 30 m, height over top of pile = 4 m. Total height is 14.5. Useful surface is 2500 m^2, total surface 3000 m^2. The aisle should be separated from the storage in such a way that no dust can enter the aisle. Therefore the open room between the roof and the L-shaped wall should be closed by corrugated asbestos-cement sidings. Openings in the L-shaped wall at regular intervals should be made; closures should be as in BI.

/...

1.3. C. Buildings with heavy walls of 4 m height. As compared with A and B these buildings still can be shorter. Moreover the length of the belt-conveyor is shorter and therefore its costs are lower, but as the building is higher the costs of the bucket elevator are higher. As well the distances from storage to production units are shorter and transportation costs are lower. However, as piles are higher there is a higher tendency for caking when stored for a long time. This might not be serious when raw materials of good quality are used. Closures of openings in the walls are more difficult to arrange and to handle.

In order to contain the raw materials a length of 85 m, a storage width of 25 m and a free space of 4 m above the top of the pile is needed. The building (see fig 1-c) can then contain 16,500 m^3 of materials or 15,000 tons. It has a useful surface of 2125 m^2.

1.3.1.C-I Calculation showed that masonry walls of 4 m high would be very thick at the base and therefore do not present a proper solution. So this type of building is not considered as a practical alternative.

1.3.2.C-II Instead of masonry walls L-shaped structures are used. The average thickness of such a structure is 25 cm; in our calculations therefore it can be neglected. The price of this type of wall is calculated to be \$850.- per m of length. The building has now as dimensions length 85 m, width 25 m, aisle 5 m; so total width is 30 m. Height over the pile is 4 m; total height is 15.5 m. Usefull surface is 2125 m^2 total surface is 2550 m^2. The aisle should be separated from the storage in such a way that dust cannot enter the aisle. Openings in the walls at regular intervals should be provided for.

/...

2. Costs of buildings

In the calculations the price of the plots have not been taken into consideration as no exact data were available. The costs of the building as a concrete structure with steel trusses and roofing and sidings made out of corrugated asbestos-cement are estimated at $125 per square meter. The costs of heavy walls of 3 m height made out of masonry were calculated by Ato Abebe Muluneh to be $243.40 per m; those of L-shaped concrete units to be $370 per m. The costs of L-shaped RC units of 4 m height are $850 per m. Masonry walls of 4 m heights are not to be recommended as they are too thick. In all cases the costs of two (movable) partition walls made out of L-shaped were added to the costs of the building. These partitions are very useful to separate different types of raw materials; as they are made out of small units they easily can be moved to meet the needs as to quantities of different raw materials.

2.1 A - type building

This building has a length of 125 m and a width of 35 m. Surface is 4375 m^2

Costs are:

Building 4375 m^2 at $125.-		$546,875.-
Partition walls (2x30 m) at $370		22,200.-
	Total	$569,075.-
	say	$570,000.-

2.2. Type B-I (see 1.2.1)

Dimensions: Length = 103 m, width 33 m, Surface = 3400 m^2. It is assumed that the wooden closures in the wall have the same costs as the wall.

Costs are:

Building: 3400 m^2 at $125.-		$425,000.-
Masonry walls (2x103+2x28 m) at $243.40		63,770.-
Partition walls 2 x 28 m at $370.-		20,720.-
	Total	$509,490.-
	say	$510,000.-

2.3 Type B-II (see 1.2.2)

Dimensions: length 100 m, width 30 m surface =3000 m^2
It is assumed that the wooden closures have the same costs as the wall.

3000 m^2 at $125.-	$375,000.-
L-shaped walls (2x100+2x25 m) at $370.-	92,500.-
Partition walls 2 x 25 m at $370.-	18,500.-
Total	$486,000.-

2.4 Type C-II

Dimensions: length 85 m width 30 m surface 2550 m^2
Costs are:

Building 2550 m^2 at $125.-	$318,750.-
L-shaped RC walls (2x85+2x25 m) at $850	$187,000.-
Partition walls 2x25 m at $850.-	42,500.-
Total	$548,250.-
say	$548.000.-

It is assumed that the wooden closures in the walls have the same costs as the wall.

3. Conclusions:

The different storages costs

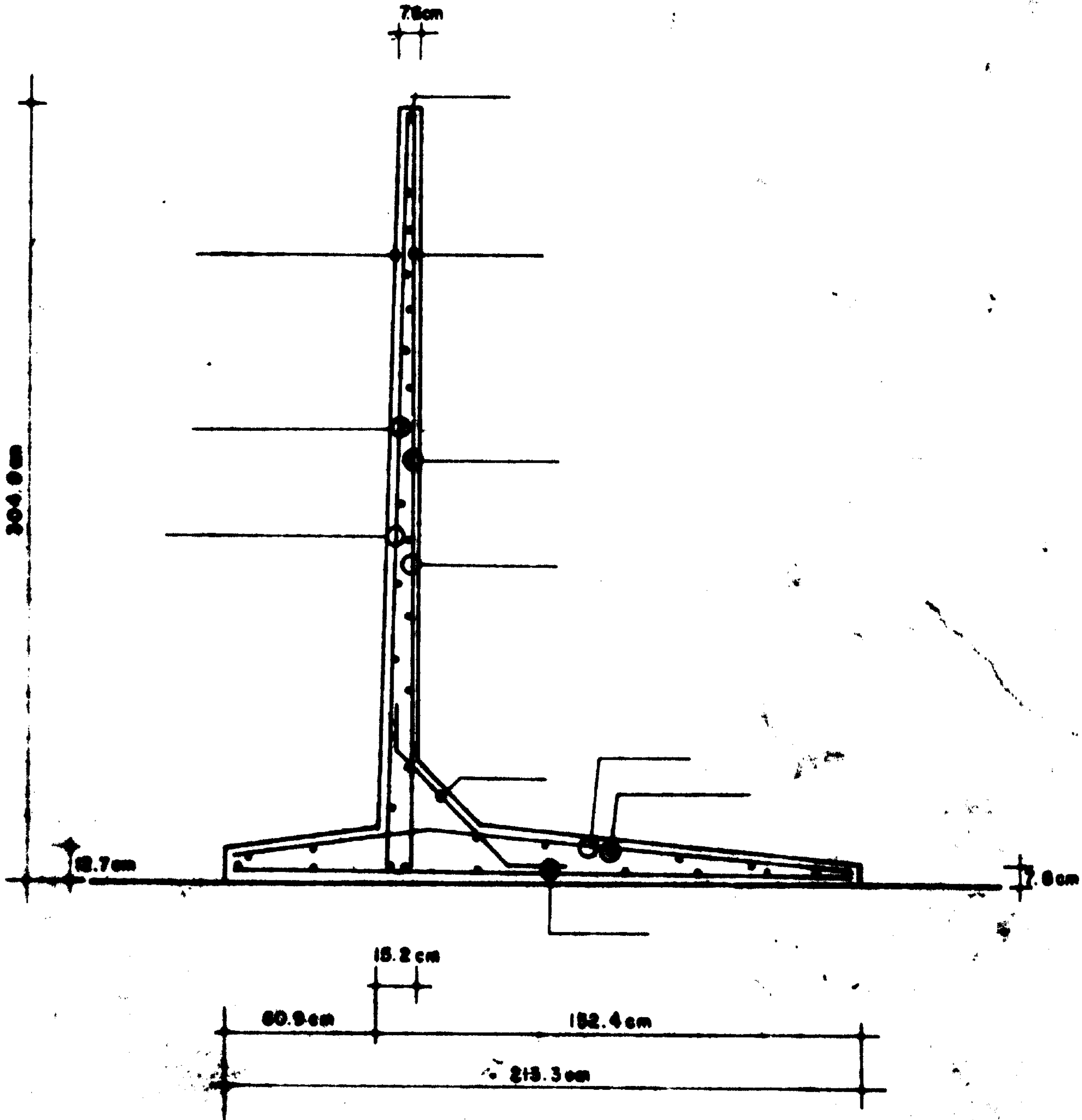
Building:	A	$ 570,000.-
"	BI	510,000.-
"	BII	486,000.-
"	CI	548,000.-

Conclusion:

The ceapest solution is B-II, being a storage with concrete walls of 3 m height and fitted with 2 separation walls to be able to store different kinds of raw materials. These separations walls are movable to meet specific needs.

The reinforced concrete walls are made out of separate sections that easily can joined together (see fig Ann 1-1). As compared with masonry walls a reinforced concrete construction has a better and more aesthetic aspect.

From a point of view of transportation problems a 100 m long building as B-II offers advantages as compared with a 125 m building as A.



L-SHAPED REINFORCED CONCRETE
WALL SECTIONS

Chapter VII - Annex 2

Meteorological Situation at Assab

1. **Introduction**

As mentioned in Chapter VII - 1.1.2.1 attention should be given to the relative humidity (RH) in Assab of the raw materials to be used. Urea has the lowest critical humidity i.e. 75.2% at 30°C. So this critical humidity never should be reached or surpassed. The other raw materials to be stored all have higher critical humidities:

Diammonium Phosphate	Critical	Humidity	=	82.8%
Triple Super Phosphate	"	"	=	93.7%
Sulphate of Ammonia	"	"	=	79.2%
Potassium Chloride	"	"	=	84.0%
Potassium Sulphate	"	"	=	96.3%

Mixtures of some of the raw materials to be blended in some cases have lower critical humidity than its components. So mixtures of DAP and Urea have a critical humidity of 62% at 30°C. It must however be kept in mind that the mixed products are bagged immediately after production. In the well sealed p.e. bag there is no possibility to absorb moisture and the lower critical humidity does not imply any danger. The farmer when using only part of a bag of fertilizer should keep the remainder well closed and in dry warm place.

2. **Seasonal variations of relative humidity**

The Meteorological Service supplied us data for temperature and relative humidity at Assab. Data from the years 1971, 1972 and 1973 were given. These are monthly average values of air temperature(t) and relative humidity (RH) taken at 6.00, 12.00 and 18.00 hr local time. Values are measured in the open air. As these are average monthly data there are higher and lower values. Variations of (RH) occasionally are as a maximum 10% above mean value and more often 5% higher. Table 1 presents the values mentioned above. It must be mentioned that the lowest daily temperatures occur about sunrise, so between 6.00 and 6.30 hr; maximum daily temperature at about 16.00 hr.

Table 1

Month		1971			1972			1973		
		6.00	12.00	18.00	6.00	12.00	18.00	6.00	12.00	18.00
January	%RH	73	57	62	71	56	61	76	59	65
	°C,T	-	-	-	24.3°	29.4°	27.4	24.0	29.3	27.4
February	RH	72	53	51	74	60	67	67	48	48
	T	-	-	-	24.0°	28.9°	27.1°	24.6	30.7	29.6
March	RH	59	43	40	70	54	55	63	51	50
	T	-	-	-	26.2	30.9	30.1	26.8	31.7	30.5
April	RH	67	44	40	65	51	52	57	44	44
	T	-	-	-	27.4	33.3	31.9	28.8	34.6	34.0
May	RH	55	50	51	55	49	52	68	58	63
	T	-	-	-	3[illegible].9	34.0	33.6	30.6	34.7	33.1
June	RH	51	46	52	57	50	58	57	54	60
	T	-	-	-	32.9	36.1	34.2	32.0	35.5	34.2
July	RH	50	46	56	50	45	56	42	39	56
	T	-	-	-	33.1	37.7	33.5	33.9	37.9	34.9
August	RH	54	52	53	52	52	59	53	47	58
	T	-	-	-	33.5	36.7	34.8	33.0	37.4	35.1
September	RH	65	60	61	64	59	63	63	61	63
	T	-	-	-	32.2	35.5	33.5	32.0	35.[illegible]	33.9
October	RH	60	52	60	60	50	52	59	48	56
	T	-	-	-	29.9	34.2	31.6	29.2	34.2	31.9
November	RH	60	50	51	68	50	56	62	48	53
	T	-	-	-	26.4	32.9	29.7	26.9	32.2	29.5
December	RH	68	56	64	75	58	62	65	50	57
	T	-	-	-	25.2	30.7	28.5	24.7	30.2	27.7

Table 1 shows that only in December, January and February relative humidity occasionally reached or depassed 75% but mostly stays below that value. Now as they are average values, they might be (as mentioned) 10% higher; therefore it might occur (January 1973) that sometimes RH = 84% and more often 79%.

Table 2 gives data about monthly extreme maximum and minimum temperatures respectively over the period 1950-1971 and of the years 1960-1961.

Table 2.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max T '50-'71	32.0	32.1	30.7	38.3	39.9	41.3	42.9	41.7	39.5	38.6	35.3	33.2
Min T '50-'61	21.0	22.0	23.0	24.0	25.0	25.0	24.0	23.0	27.0	23.0	23.0	21.0

It can be observed that the high values of RH only occur at 6.00 o'clock, but that during day time RH is much lower and as a matter of fact never reaches a critical value even when 10% is added. The rise of RH in the early morning is due to the drop in temperature of the atmosphere during the night. The air mainly cools down due to radiation losses but as is shown in the calculation below the partial pressure and consequently the amount of water vapour remains the same. From known values of saturation pressures of water vapour and of the observed RH's the partial water vapour pressures, that represent the actual amount of humidity, can be calculated. For January 1973 we thus obtain the data of table 3.

Table 3.

January 1973				
Time	Temp.	Sature. pressure in mm Hg.	RH	Partial Pressure in mm Hg.
6.00	24.0°	23.4	76%	17.9
12.00	24.0°	30.6	59%	18.0
18.00	27.4°	27.4	65%	17.8

The same calculations for the situations with 10% and 5% higher RH at 6.00 hr. give the data of table 4.

Table 4.

Time	Temp.	Satur. Pressure	RH	Partial Pressure
6.00	24.0	23.4	76%	17.8
6.00	24.0	23.4	80%	18.7
6.00	24.0	23.4	84%	19.7

We will use these data in further calculations.

3. Influence of temperature

As mentioned the reason for the temperature drop of the air is heat-loss by radiation. Therefore in a closed building the temperature drop will be far less and consequently RH will be lower. In calculating the RH under conditions of 26°C respectively 27°C we obtain the values of table 5 (related to Jan' 73, 6.00 hr)

Table 5

a	b	c	d	e	f
RH at 24°C	Partial pressure	Saturation pressure at 26°	RH at 26°C b:c	Saturation pressure at 27°	RH at 27°C b:e
76 80 84	17.8 18.7 19.7	25.3 25.3 25.3	70 74 78	26.7 26.7 26.7	67 70 74

Table 5 shows that in the most extreme situation a temperature rise of 3°C will bring the RH below the danger level. Now it is quite probable that the reduced radiation of heat inside the building will prevent the temperature to drop below 27°C. If not a slight heating of the storage room will prevent a sharp temperature drop.

Assuming we have the situation of the storage as mentioned **Chapter VII - Annex 1 alternative B 11.**
This storage has a total volume of 28,700 m^3 and a volume of air of 11,800 m^3. Its floor surface is 4250 m^2, as the roof has a slope of 30° roof surface is about 5000 m^2. Side walls above the 3m of thick walls have a surface of about 800 m^2. Total surface is 5800 m^2 say 6000 m^2.

11,800 m^3 of air weigh 14,000 kg. Specific heat of air is 0,242. To raise the temperature 3°C about 10,000 Cal are needed which is the heat produced by the combustion of about 1.4 kg. of charcoal. (heat of combustion 7000 Cal/kg). But in order to keep the temperature at the desired level it is necessary to compensate for the heat losses through roof and side walls.

Assuming a loss of 4 Cal per °C per hour per m^2, these losses for a difference in temperature of 3°C and for 6000 m^2 are equal to

4 x 3 x 6000 = 72,000 Cal per hour. This amount of heat can be produced by burning about 10 kg. of charcoal as an open fire. Assuming that it is necessary to heat during 8 hours, the total amount of charcoal will be about 80 kg. Adding 25% for other losses the amount will be 100 kg.

Charcoal should be used for the open fire because its combustion products do not contain water vapour. Liquid fuels, being carbon-hydrogen compounds, all produce water vapour when combusted. So these latter products should not be used for these purposes.

It will however, only occasionally be necessary to heat the storage. Using a hygrometer and a thermometer in the storage of raw materials, preferably recording instruments, it can be foreseen when extra heating is necessary. Covering the piles of urea with plastic sheets also is a measure to deal with the humidity problem. It is not necessary to install special equipment to dry the air in the storage room.

4. Conclusions

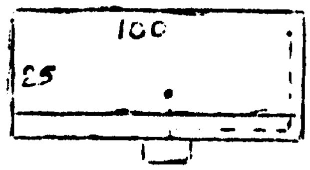
Meteorological conditions in the Assab area but seldom give raise to situations of high relative humidity (RH). Only in the months December, January and February during night time in the open air RH's greater than 75, which is the dangerous level for urea, are measured. However, in many years even this value is not reached in said months.

As the high RH values are due to heat losses of the air through radiation, the situation inside the storage building will be much favourable. It is likely that within the building the temperature drop and consequently the rise of RH will be such that a critical situation will not or very seldom be reached.

If so some heating, using an open charcoal fire, will be sufficient to keep the RH below a dangerous level.

Ch VII - Annex 3

Transportation of Raw Materials
from Storage to Mixing and Bagging Plant



Max. distance: (50+25)x2 = 150 m.V.V
15x2 = 30 m
Average distance 90m

A. Transportation by payloader

Velocity: 18 km/hr = 5 m/sec.
time schedules:

for distance:	90 m	150 m	30 m
driving	18 sec	30 sec	6 sec
pick up + manoeuvering	10 "	10 "	10 "
unload + manoeuvering	10 "	10 "	10 "
waiting, fueling	8 "	8 "	8 "
cycle	46 sec	58 sec	34 sec
per hour :	78 ton/hr	62 ton/hr	106 ton/hr
at cap. bucket 1000 kg	78 ton/hr	62 ton/hr	106 ton/hr
1200 kg	93 ton/hr	75 ton/hr	127 ton/hr
1500 kg	117 ton/hr	93 ton/hr	159 ton/hr

necessary for 80 ton/hr (40 ton mixes + 40 ton straights) 1 to 2 payloaders (1-2 drivers) depending on capacity. With sufficient capacity 2 payloaders of which one as stand by will be sufficient.

B. Transportation by handcarts

Each cart can hold 1000 lbs = 450 kg, for transportation 4 men are required. To fill one car with shovels by 4 men 2 min. are needed. As a persons performance is about 20 shovels per min: 4 people can do 80 shovels at 3 kg per shovel = 240 kg/min. So time required is 2 min, velocity is 3 km/hr = 0.83 m per sec.

Time schedules:

For distances	90 m	150 m	30 m
Driving	108 sec.	180 sec.	36 sec.
Loading	120 "	120 "	120 "
Unloading	60 "	60 "	60 "
Rest, waiting	15 "	18 "	12 "
Cycle	303 sec.	378 sec.	228 sec.
per hour	11 trips	9 trips	15 trips
per hour per cart	4.95 ton	4.05	6.75 ton
for 80 t/hr needed:	17 carts	20 carts	12 carts
personnel needed			
4 man per cart:	68 man	80 man	48 man

/...

So 20 carts as a maximum are needed; as an average 18 are used. At least 25 carts should be available. There are two places where the materials have to be unloaded; the mixing unit and the bagging unit. At each unit 40 ton has to be unloaded per hour. As each load equals 0.45 ton 89 unloading actions have to be performed at each unit. As each action takes 1 min. two unloading devices per unit are needed.

The transportation of 3 to 4 different materials to be controlled by a light signal system and using a great number of transportation units will pose many organizational problems. Several foreman each controlling 7-10 carts will be necessary.

In the calculation given above it is assumed that each crew performs the entire cycle of loading, transportation and unloading. Another working method would be to have separate crews for transportation and for loading. It can be shown that both methods have the same capacities. The former method however is simpler to control and is automatically adjusted to the time of the transportation cycle. Moreover the work for the crew is less monotonous than in the latter case.

Costs:

A. Use of payloaders:

Investments costs at $84,000 each	$168,000
Operating costs: Interest 10%	16,800
Depreciation 10%	16,800
Insurance 5%	8,400
Fuel	15,000
Tyres (4%)	6,700
Maintenance 6%	10,800
Salaries 1 driver at $350/month	8,400
	$82,900

Operating costs per ton at 100,000 t/year in 220 days are: $0.83 at 200,000 t/year in 330 days ($7500 extra fuel) costs are $96,400 or $0.45 per ton.

B. **Use of handcarts**

Investment costs	
1 car plus lifting and towing equipment is assumed	
to cost $2000. So 25 carts cost	$50,000
1 gantry plus hoist is assumed to cost $2000	
So four gantries cost	8,000
Total investment	$58,000

/...

Operating costs	
Interest 10%	$5,800
Depreciation 10%	5,800
Insurance 2%	1,160
Maintenance 2%	1,160
Wages 2 foremen at $200/month	4,800
Wages 80 labourers at $150/month	144,000
Total operating costs	162,720

Operating costs per ton at 100,000 ton per year are $1,627

CONCLUSION:

Comparing the two methods of transportation of raw materials to the mixing and bagging units conclusions are:-

1. Investment costs when using mechanized transportation are higher as compared with manual transportation. Respectively $168,000 when two payloaders are purchased and $58,000 when hand transportation is used.

2. Operating costs are considerably higher with manual transportation. Mechanized transportation costs per ton $0.79 using 2 payloaders. Manual transportation costs $1.63 per ton.

3. Organization of the transportation of different products in the proper sequence to the mixing plant is more complicated in the case of manual transportation. This means a great stress to the foremen responsible for faultless operations; their constant attention is an absolute demand.

4. Apart from conclusions 2.3 which are in favour of mechanized transportation social considerations might lead to a different conclusion.

Chapter VII

ANNEX 4

Schedules for operation of the mixing and bagging plants

a) Feeding of the mixing plant and of one of the bagging units with wheelloaders. Two cases are considered: 1200 and 1500 kg. loads. Average cycle for each load is 50 sec which means capacities are 86 and 108 tons per hour for both mixing and bagging units or 43 respectively 54 tons for each of them. The capacity of the bucket elevator is 80 tons per hour or 22.5 kg per sec. The height of the elevator is 18 m. its velocity is 1.2 m/sec; therefore the height is covered in 15 sec. The bottom of the elevator has a hold up of about 500 lit. = 450 kg and can be emptied in 45 sec.

When three loads of 1.5 ton are filled into the hopper the elevator needs $\frac{4500}{22.5}$ = 200 sec for transportation; including emptying the bottom etc; total time is 260 sec. After having dumped three loads into the mixing plant's hopper, the payloader supplies the bagging unit for straight fertilizers with three loads of 1.5 tons each. As a cycle takes 50 sec. the pay loader can start again to supply the mixing plant 300 sec after the first time. This means 40 sec. after its elevator has transported the first batch of 3 loads. Therefore every 300 sec a new component can be transported to the four compartment hopper. Each compartment of this hopper should have a hold up of about 6-6.6 tons or 6.7-7.3 m^3. A hopper of dimensions of 2.8 x 2.8m, being composed of a prismatic section of 2.8 m of height and a pyramidical part of 2.8 m of height has a volume of $29m^3$ or $7.3m^3$ per compartment.

When four loads of 1200 kg are filled into the hopper using cycles of 50 sec the elevator needs 4800: 22.5=214 sec for transportation, when adding 60 sec total time will be 274 sec. when four loads are dumped into the hopper of the mixing plant, the payloader supplies the bagging unit with four loads (4.8 tons). Therefore after 400 sec the payloader can feed the mixing plant with a new supply of 4.8 ton. The four compartment hopper with holds of $7.3m^3$ or 6.6 tons each as mentioned before can handle the amounts to be processed. The time schedules of fig. Annex IV 1^a, 1^b illustrate the flows of materials to both mixing and bagging unit. In the mixing plant the flow up to the 4-compartment hopper is considered.

Having set up the schedule to feed the mixing and bagging plant, the material flow within the mixing unit has to be considered.

b) <u>Activities in the blending plant</u>

They comprise weighing of 3 or 4 components, mixing activities including loading and discharge as well as final transportation to the bagging units. Time schedules for 2 tons mixes and cycles of 2 min resulting in an hourly capacity of 60 t/hr as well as for 2.5 tons mixes and cycles of 3 min with a capacity of 50 t/hr were made.

<u>2 tons batches, cycle = 2 min;</u> capacity = 60 t/hr
Assumed is a weighing performance of 25 sec. (20" coarse and 5" dribble feed) per component and 20 sec for emptying the weigher into the mixer. Total cycle is 120 sec. or 2 min. In 20 sec the empty mixer is filled. Assuming a mixing time of 100 sec 20 sec are available for discharge into the hopper. It depends on the parameters of the mixer what the exact time of discharge will be. During filling and discharge the mixing performance goes on. See fig. Annex 4. 1.c.

<u>2.5 tons batches, cycle</u> = 3 min; capacity= 50 /hr
Assumed is a weighing performance of 35 sec (30" coarse and 5" dribbled feed) per component, 40 sec are available for discharging the weigher.

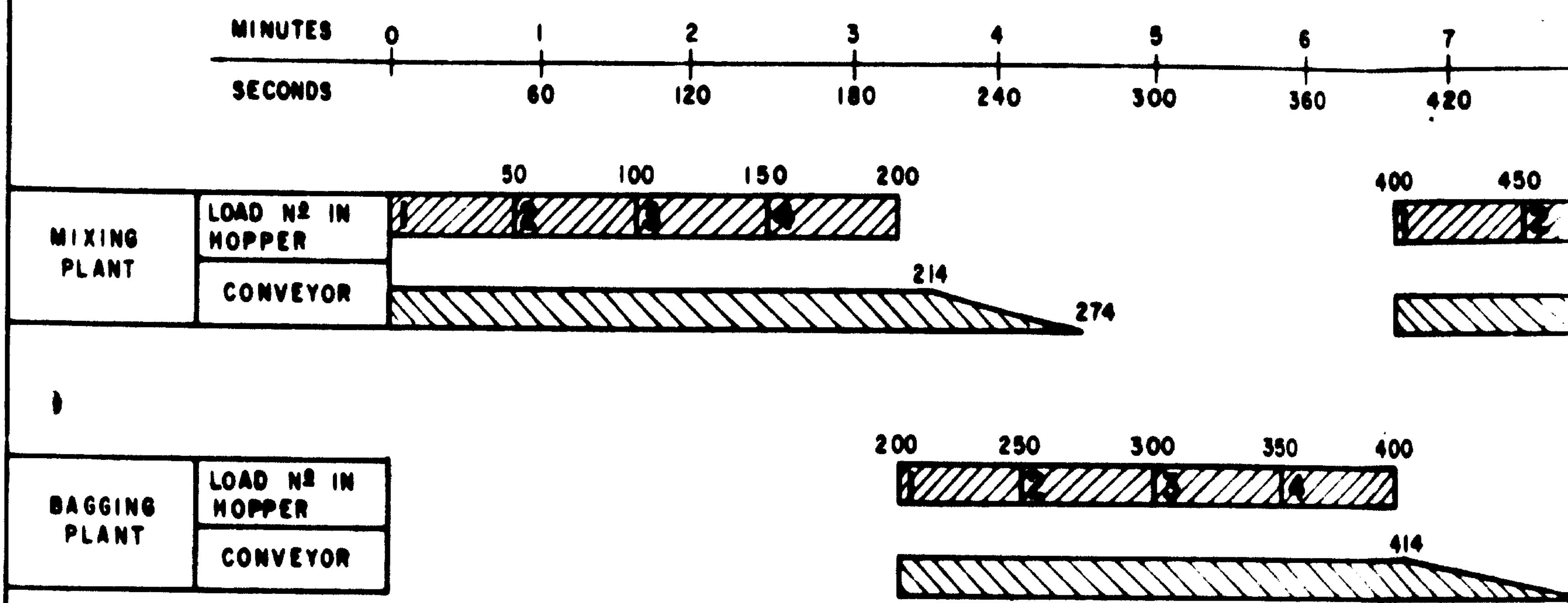
The mixer is loaded in 40 sec or less and mixing can be continued up to 140 sec, leaving 40 sec for discharging into the hopper. The 2.5 ton batch has to be discharged to the elevator of the bagging unit at a minimum rate of 14 kg/sec or 50 tons per hour, which is well under the capacity of the elevator. At full capacity 112 sec are needed to convey the 2.5 tons batch. (See fig. Annex 4-1 d).

It must be kept in mind that the above mentioned times and capacities are related to high capacities and to the maximum of four components.

As a matter of fact in the majority of mixes only 3 components are needed, one of them (filler) in only small quantities. Therefore, it can be concluded that sufficient time is available to produce 40-50 tons of mixes per hour.

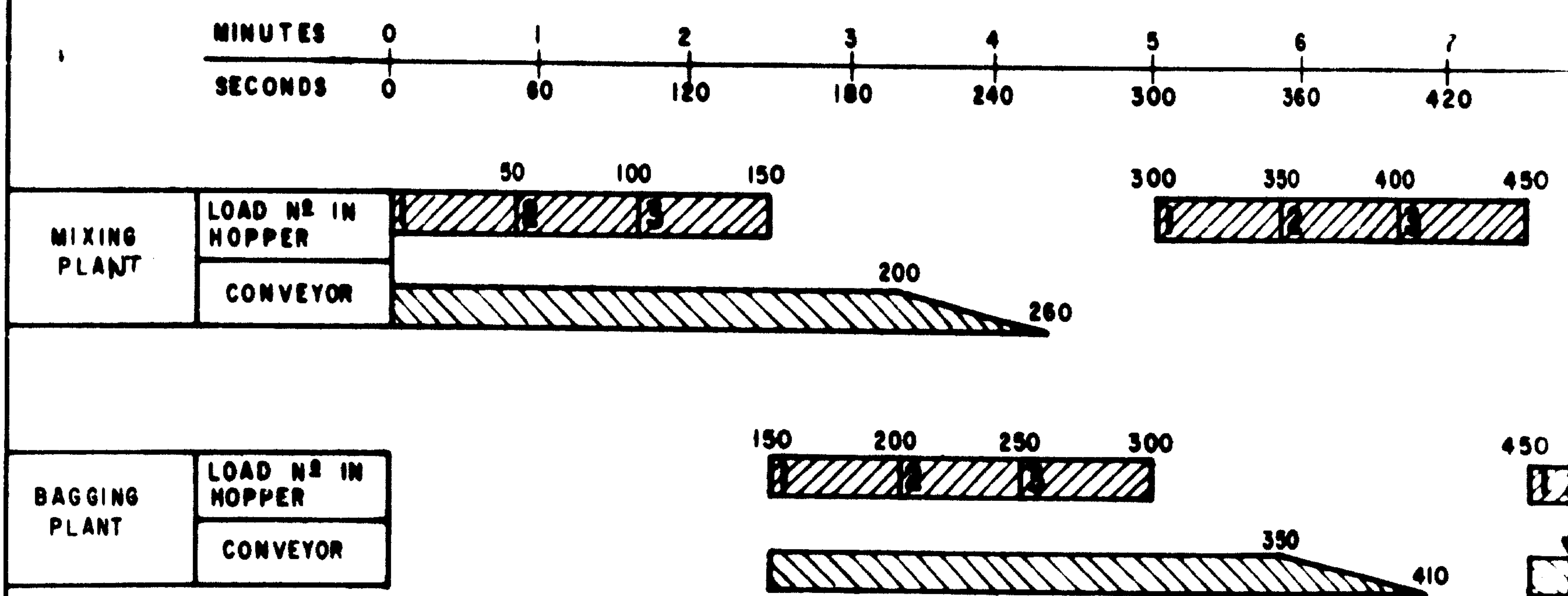
FEEDING OF UNITS WITH LOAD

Fig 1-a



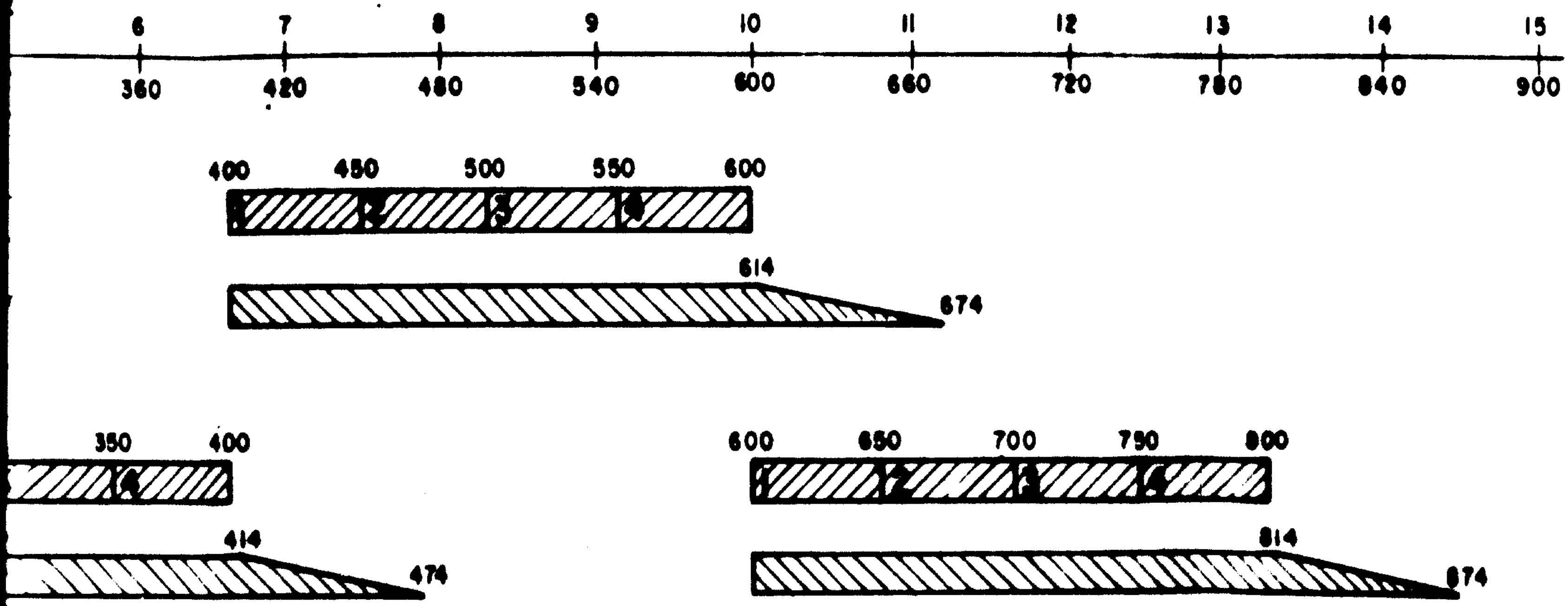
FEEDING OF UNITS WITH LOAD

Fig 1-b



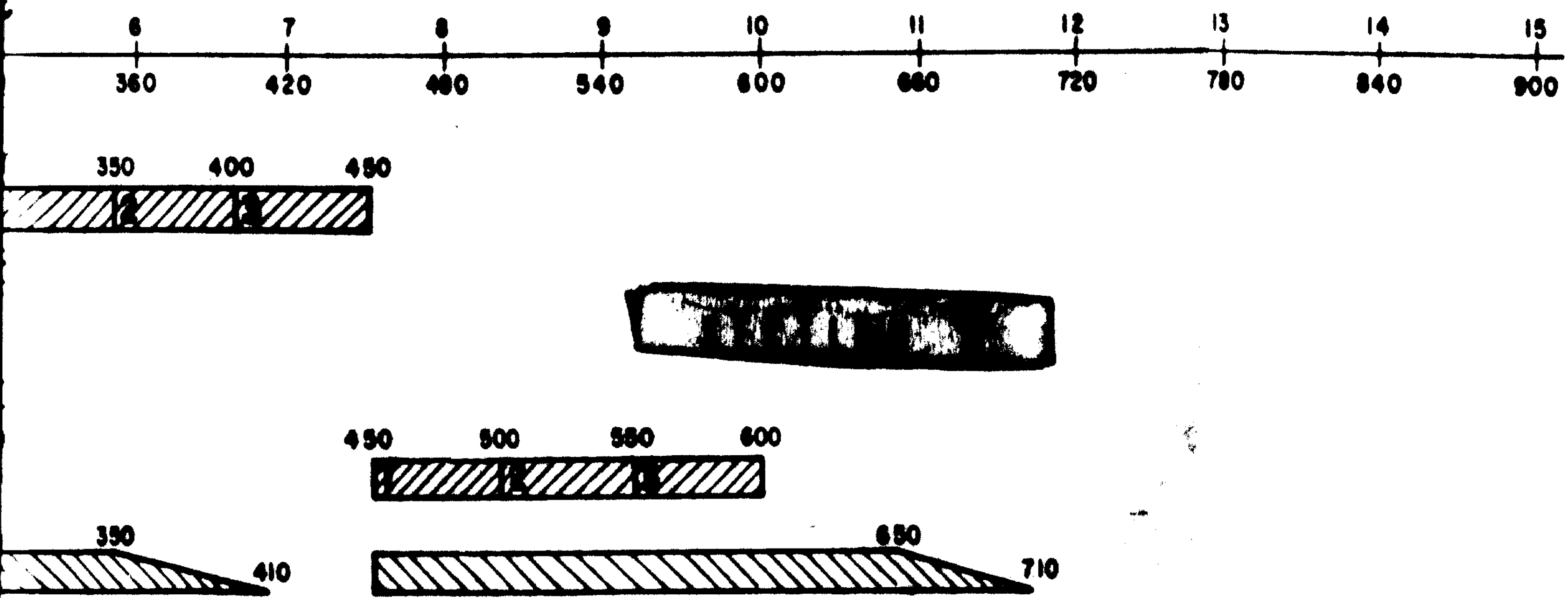
NITS WITH LOADS OF 1.2 TONS

Fig 1-a



NITS WITH LOADS OF 1.5 TONS

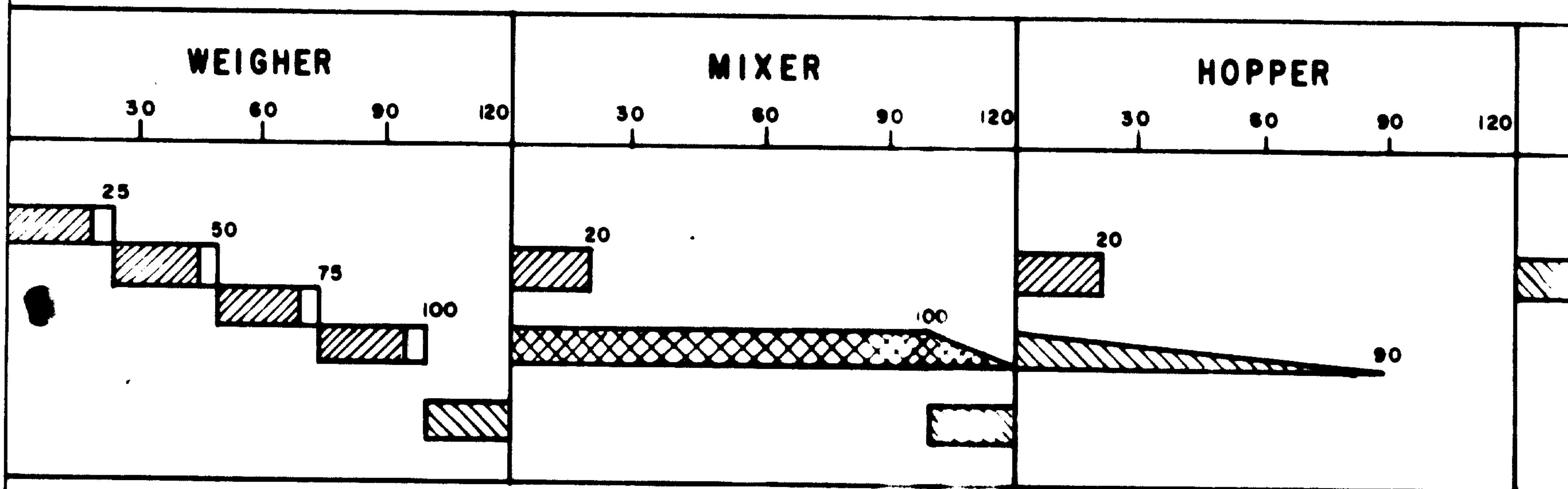
Fig 1-b



FLOW THROUGH MIXING UNIT

CYCLE = 2 MIN; BATCH = 2 TONS CAPACITY = 60 T/HR.

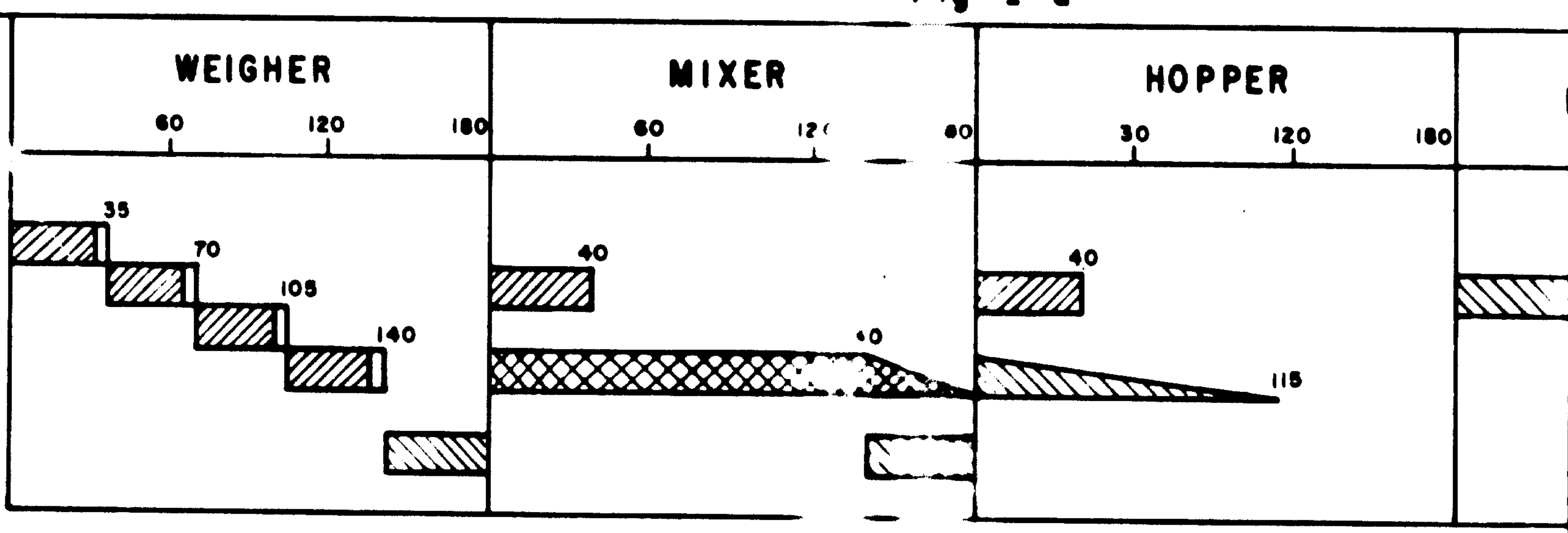
Fig 1-c



FLOW THROUGH MIXING UNIT

CYCLE = 3 MIN, BATCH = 2 5 TONS CAPACITY = 50 T/HR.

Fig 1-d



FEEDING

DISCHARGING

FUNCTIONING [redacted]

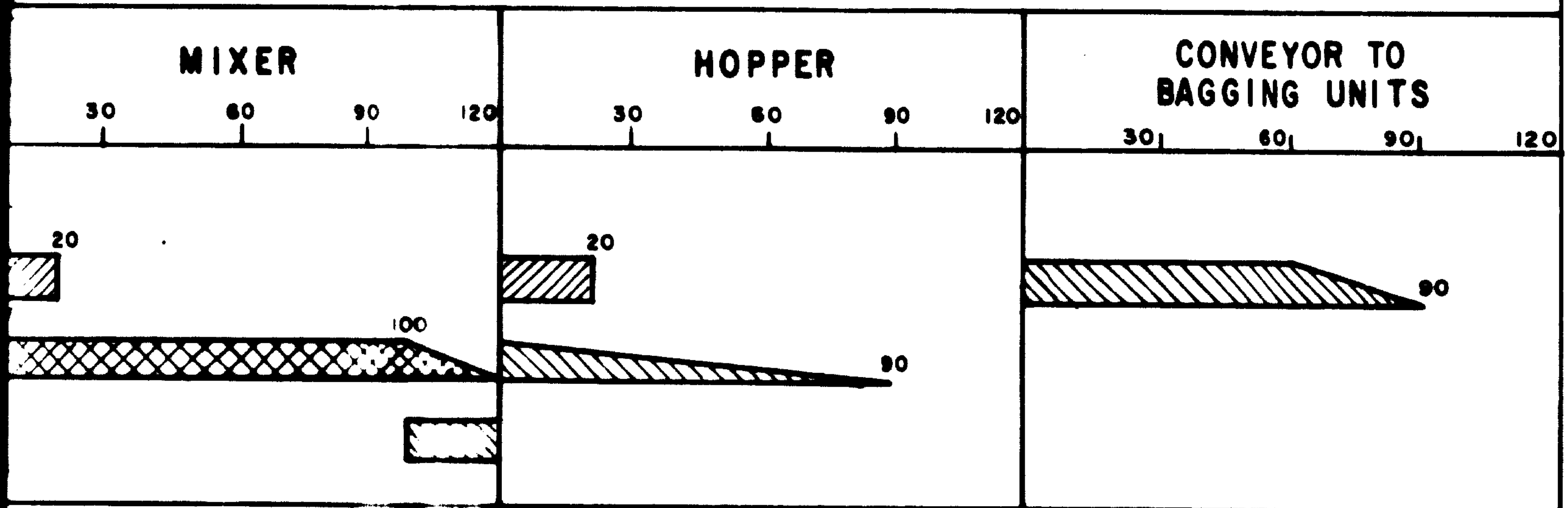
DRIBBLE FEED

Ch A ig-1

FLOW THROUGH MIXING UNIT

YCLE = 2 MIN; BATCH = 2 TONS CAPACITY = 60 T/HR.

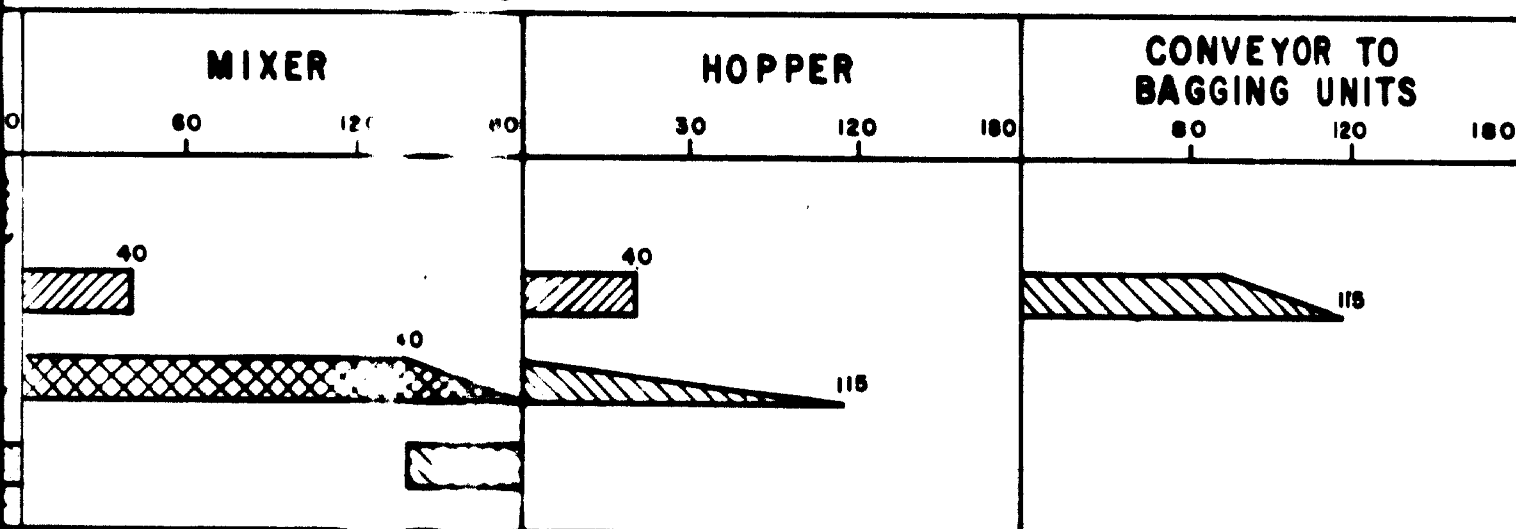
Fig 1-c



FLOW THROUGH MIXING UNIT

CLE = 3 MIN, BATCH = 2 5 TONS CAPACITY = 50 T/HR.

Fig 1-d



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Ch A Fig-1

Chapter VII

Annex 5

Storage and Handling of Bagged Materials

1. Storage of bags can either be done by using pallets to be transported by forktrucks or by storing the bags on piles by manual labour.

1.1. A. Pallets. A pallet of 1050 x 1300 and a height of 140 mm can carry 30 bags or 1.5 ton in 6 layers of each 5 bags. Total height of a loaded pallet is 1100 mm. A forklift truck can carry 2 pallets on top of each other. Stacks can be 5 pallets high; an average type of lifttruck can carry 3.5 ton and lift to 5,5-6,0 m.

Each pallet needs a surface area 1.5 m^2, this means, that when piling 5 pallets on top of each other, 5 tons can be stored per m^2. To store 10000 tons 5000 pallets and a surface of 2000 m^2 are needed. Adding 20% for manoeuvering and driving of lifttrucks and eventually trucks a surface of 2400 m^2 is needed. A shed of 65 x 40 fulfils this need, a height of 6.0 m under the trusses enables piling of 5 pallets leaving space for lifting operations. In such a building an aisle of 6 m is available for manoeuvering. The floor has to be flat in order to ensure safe operations of forktrucks. One forktruck can handle the output of 2 bagging units (80 tons/hour)(see 2.1). Two forktrucks of which one as standby should be purchased.

When the building is extended to 80 m and provided with a separation wall, the section of 15 x 40 m can be used as workshop. If further extensions ask for a large workshop somewhereelse on the premises this part could be added to the storage of bagged products, thus enlarging its capacity to 12,300 ton.

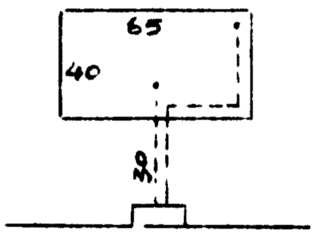
1.2. B. Piling by manual labour asks for about the same space. As there are no pallets which each have height of 140 mm more bags can be piled on a square meter, but in order to have a good stability separate piles are necessary. So the same size of building as in A is suitable, piling will be limited to 5 m.

1.3. Costs:

The building excluding space for a maintenance shop has overall dimensions of 65 x 40 m surface is 2600 m^2. Costs including a heavy floor will be $125 per m^2 or $325,000.

2. Calculation of Performance

2.1. A. Pallets and Forktruck Transportation



max. distance 2 x 100 m = 200 m
min. " 2 x 40 m = 80 m
average" = 140 m

Average driving speed of lifttruck = 18 km/hr = 5 m/sec

Time Schedule

Distance	200 m	140 m	80 m
Driving	40 sec	28 sec	16 sec
Pickup, manoeuvering	12 "	12 "	12 "
Unloading	12 "	12 "	12 "
Waiting, fueling	8 "	8 "	8 "
cycle	72 sec	60 sec	40 sec
Trips per hour	50 trips	60 trips	75 trips
cap. per hour	150 ton	180 ton	225 ton

The situation for maximum duty for forktrucks implies transportation of all bagged products into the storage plus loading of trucks out of the stocks from the storage. As maximum production is 80 tons of bags per hour, only half the time, in the most unfavourable situation, is used for transportation to the storage. 70 tons can then easily be transported from the storage to the trucks and even more as the average distance to the truck is shorter and manupulation is easier. So one forktruck can do all the work needed; another forktruck as standby is recommended.

The situation outlined above will exist only occasionally. Most of the time it will be possible to load trucks directly from the output of the bagging units. In case it is possible (with two units) that no material at all has to be transported to the storage and if necessary the forktruck can load from the storage

150-200 tons on trucks. The practical situation will be in between these two extremes; so one forktruck can meet all possible situations.

Apart from the forktruck driver manual labourers are needed for loading pallets and loading trucks. Four gangs of each four man or 16 labourers will be sufficient.

2.2. B. Transportation by manual labour

2.2.1 In this case transportation is done using wheelbarrows each carrying 4 bags or 0.2 tons. They have a driving speed of 3 km/hr or 0.83 m/sec. Each bagging unit delivers 40 ton or 800 bags per hour or 1 bag every 4.5 sec say 5sec. Four bags or 0.2 tons take 20 sec.

Distances are as in A.

Time Schedule

	200 m	140 m	80 m
Driving	240 sec.	169 sec.	96 sec.
Loading	20	20	20
Unloading	6	6	6
Waiting, rest	18	16	12
cycle	284 sec	211 sec	134 sec.
Trips per hour	12.6	17.1	26.9
cap. per hour per man	2.5	3.4	5.4
labourers for 80 ton/hr	3.2	2.4	15

So 15-32 labourers are needed

2.2.2. Piling 2 man for each m of piling + 2 on top of the pile are needed. This means 12 m for 5 m high piles and 4 for piles upto 1 m. Average 8 man. At a speed of 8 (7) bags per min each shift can pile 480 (420) bags per hour or 24 (21) tons. For 80 tons therefore 3.3 to 3.8 shifts of 8 man are needed. So 32 man or 4 shifts.

2.2.3. Breaking down piles. The same shifts as in 2.2.2 minus 2 man = 6 man as an average. Performance is higher 12 (10) bags per min can be achieved or 720 bags (600) = 36 tons (30) per hour; 80 tons ask for 2.2 (2.6) shifts. This means about 18 labourers.

Breaking down can be done by the same labourers that construct piles as these two activities never or only but very seldom have to be done at the same time.

2.2.4. Transportation to trucks. This has to be done by wheelbarrows. Distance is short as trucks can come near the storage; 30 m as an average will do. Loading and unloading of the barrows can be done in resp. 30 and 12 sec. Time needed per cycle is then, assuming cartloads of 4 bags

Driving	60 m =	72 sec.
Loading		30 "
Unloading		12 "
Waiting, rest		10 "
		124 sec

Per hour 29 cycles or 5.8 tons. For 80 ton per hour 14 units are needed.

2.2.5. Loading of trucks. A shift of 4 man can load 8 (7) bags per min or 480 (420) bags = 24 (21) ton per hour. For 80 ton 3.3 (3.8) shifts are needed; so 16 labourers.

2.2.6. Resuming: for bringing into the storage and piling (64) labourers as a maximum are needed. For outloading the storage are needed 18 + 9 + 16 = 43 man.

As either the storage is going to be filled or to be emptied, because both activities hardly will be needed simultaneously, the same crews can perform both activities. It must be kept in mind that loading of trucks directly from the bagging machines will be current practise. This the more so as costs will then be low. So a crew of 64 labourers plus two foremen can handle the production as to all activities with bagged products.

2.3. C. An intermediate between palletised and manual operation is to do the transportation by wheelbarrows but to perform piling with the use of special equipment. For piling activities a movable belt conveyor that can be adjusted to bring the bags from the floor upto the top of the pile (say max. 6 m) directly to the 2 labourers who construct the pile. Such a conveyor has a special belt in order to permit a steep slope. The capacity of such a conveyor is 50-75 ton/hour; energy demand is about 10 HP = 7.5 kw. Two of these conveyors, that can be used for construction of piles as well as for breaking them down, are needed. Costs are estimated at $20-25,000 each. When using this type of equipment only four labourers are needed per conveyor plus the labourers for transportation. This brings the total personnel down to 32 + 8 = 40 labourers plus 1 foreman.

This type of piling has the definite advantage of more careful handling as compared with entirely manual piling and therefore less bags are expected to be damaged.

4. Costs

4.1. A. Using forktrucks and pallets

Investments: 2 forktrucks at $60,000	$120,000
5000 pallets at $15 (16 pallets per m^3 of wood = $240/$m^3$ worked up)	75,000
Contingencies 15%	29,000
Building	325,000
Total	$549,000

Operating costs:	
interest 10%	54,900
depreciation, equipment 10%	22,400
depreciation, building 5%	16,250
insurance 2%	10,980
maintenance, equipment 6%	13,440
maintenance, building 1%	3,250
fuel	7,500
tyres 4%	5,880
1 driver $350/month	4,200
1 foreman $250/month	3,000
16 labourers $150/month	28,800
Total	$170,600

When 100,000 tons are handled costs are $1.71 per ton.

B. Transportation by manual labour

Investments are:

40 wheelbarrows at $60 =	$ 2,400
Building	325,000
	$327,400

Operating costs are:

Interest 10%	32,740
Insurance 2%	6,550
Depreciation, building 5%	16,250
Depreciation, equipment 20%	480
Maintenance, building 1%	1,800
Wages 64 labourers	115,200
Wages 2 foremen	6,000
	179,140

When 100,000 tons are handled costs are $1.79 per ton.

C. Transportation by manual labour plus piling equipment

Investments are:

40 wheelbarrows at $60	2,400
2 special belt conveyors at $25,000	50,000
	52,400
Contingencies 15%	7,900
Equipment	60,300
Building	325,000
Total	385,300

Operating costs are:

Investment costs	38,530
Insurance 2%	7,710
Depreciation, building 5%	16,250
Depreciation, equipment 10%	5,750
Depreciation, equipment 20%	550
Maintenance, building 1%	3,250
Maintenance, equipment 3%	1,810
Electricity 15 KW.hr = 26,400 KWH at $.08	2,110
Wages 40 labourers	72,000
Wages 1 foreman	2,400
Total	$150,360

When 100,000 tons are handled costs are $1.50 per ton.

5. Conclusions

Investment costs, yearly operating costs, ditto per ton and manpower are presented below for the three cases mentioned above.

A. Handling with forktrucks and pallets
B. Handling entirely by manual labour
C. Handling partly by manual labour, partly mechanically.

A.

	Investment	Labour	Operating Costs	
			Per Year	Per Ton
A.	$549,000	18	$170,600	$1.70
B.	$327,400	66	$179,140	$1.79
C.	$385,300	41	$150,360	$1.50

The best choice is alternative C as investments are moderate and operating costs are low.

Moreover C as compared with A enables to create employment. As compared with B alternative C offers better prospects for gentle and careful handling of bags.

CHAPTER VIII
UTILITIES AND AUXILLARY SERVICES

VIII - 1. Water

In Phase I no process water is needed, only sufficient water for cleaning purposes has to be available. Water is available from the nearby main conduct system that has to be extended to the factory site. $25,000 is supposed to be needed including contingencies and erection. Enough water should be available to extinguish a fire.

VIII - 2. Power

The main power line is at short distance. Requirements are 600 m of powerline 15 kV, 100 KW, a transformer station and switchgear as well as a power distribution and lighting system. Costs including erection and contingencies are estimated to be $100,000.

VIII - 3. Workshop

As discussed in Chapter VII-1.1.6 a space of 600 m^2 being part of the storage of bags could contain the workshop. In a later phase this space could be added to the storage of bags and a separate large workshop could be erected. The 600 m^2 workshop should contain the mechanical, the electrical and the garage equipment. Costs of the building are estimated to be $75,000. Equipment costs including erection and contingencies are $32,000. Equipment includes tools, drilling and welding machinery,, worktables. Electrical tester and meters. Guarage equipment. No heavy tools like latches are foreseen.

VIII - 4. Filler material quarry facilities

An investigation as to what filler material is available in the Assab area is going to be carried out by geologists of the Ministry of Mines. But this investigation has not yet been made. Most probably there are deposits of coral sand and of sands of basalt rock origin nearby and if so only excavating and sieving operations are necessary. If not limestone has to be quarried and processed. Processing includes size reduction and screening. At present it is very difficult to make a cost estimate. An amount of $300,000 seems to be a fair estimate.

VIII - 5. Fuel-supply

Trucks, payloaders (and forktrucks) need to be supplied with diesel-fuel. Consequently a filling station should be erected. It is supposed that one of the oil companies will provide such a station, therefore no investment costs are provided for.

VIII - 6. Office

A building of 200 m^2 should contain office rooms, laboratory, canteen and a first aid room. The building costs are estimated to be $60,000 including contingencies etc. Equipment considered follows:-

VIII - 6.1. Office Equipment and Furniture

This item includes calculator, typewriters and duplicator. Furniture includes desks, chairs, cupboards, bookshelf, filing cabinets and the like. Moreover sanitary installation and telephony. Costs are estimated to be $24,000 including contingencies.

VIII- 6.2. Canteen equipment includes refrigerator, coffee machine, furniture and miscellaneous. Costs are estimated to be $8,400 including contingencies.

VIII- 6.3. First aid room

Equipment needed should be discussed with a local physician. A rough cost estimate is $5,000.-

VIII- 6.4. Laboratory

The laboratory should contain ample equipment for the analysis of raw materials and products. The laboratory should contain a working space and a separate small room to contain balances and sensitive instruments. The working area should contain a bench equipped with gas, electricity, water and drain facilities as well as a hooded bench with ventilation. Benches should be fitted with a shelf, drawers and chests. A cupboard to contain glassware and chemicals should be present. The instrument room should contain a vibration free table.

Equipment should consist of:-

Furniture	$ 2,300
An analytical semi-automatic balance ±0.1 mgr.	1,500
A balance ± 5 mg.	300
A photoelectric colorimeter	5,000
An electrical water bath	300
An electrical drying cabinet	500
An electrical oven for crucibles	500
Burners, tripods, clamps etc	500
Glassware	800
1 set of test sieves	500
Water distilling apparatus	800
1 set of analytical weights	200
Miscellaneous	1,800
	$ 15,000
Freight, insurance, clearing etc. including contingencies 30%	4,500
	$19,500

Some instruments have to be used in and near the storage for raw materials in order to control relative humidity and temperature. These instruments should be taken care of by the laboratory chemist. Recording as well as indicating instruments should be used. Two recording hygrometres and two recording thermometers will cost $ 4,000

5 indicating hygrometers and 5 indicating thermometers will cost 400

Total $ 4,400

Including freight etc, and contingencies 30% costs are 5,700

VIII-6.5. Apart from the buildings mentioned in this chapter and in chapter VII several civil works has to be provided for including:

Access roads, 400 m long, 6 m wide	$ 36,000
Fencing in stone 2 m high above ground level 50 cm thick and foundation(1m), including gate and guard room	80,000
Compound streets and parking area	53,000
Gardening	3,000
	172,000
Contingencies 15%	26,000
Total	$198,000

CHAPTER - IX

MATERIALS AND BAGS

Granulometrics:

IX-1 The most used raw materials will be diammonium phosphate (DAP) and urea. Together they will amount to over 90% of the Ethiopian consumption; small amounts of sulphate of ammonia (SA) and potassium chloride and potassium sulphate will be used. It is assumed that in the beginning 50% of the fertilizers used will be used as mixed fertilizers and gradually this amount will rise to 75% (See Chap.III-5.2). Therefore the properties of the raw materials should be such that they can be used in mixing operations. Stable mixtures can be obtained if no segregation does occur. Segregation is the unmixing during handling, storage and transport. The main reason for segregation is the difference in particle size. All components to be blended should therefore have granules in the same range of sizes.

Now there is no general accepted standard range of granule size. When purchasing raw material it should be kept in mind to buy uniform and properly sized materials.

Urea prills generally have dimensions between 1.0 and 1.7 mm. A common size of urea granules and of other fertilizers in the U.S. is 1.4 - 2.8 mm, whereas in most European countries a large size is preferred (2.5 - 4.0 mm or 2.0 - 3.5 mm).

In the U.S.A. granule size is expressed in Tyler mesh data. In European countries mm sizes are used. The data refer to the dimensions of the openings in a standardized set of test sieves and often the particle size range is expressed as the percentage that pass one sieve and remain on another sieve. Table IX-1 presents the relation between Tyler mesh and metric dimensions.

/...

TABLE IX - 1

Tyler mesh	mm	Tyler mesh	mm	Tyler mesh	mm
60	0.246	16	1.00	8	2.38
48	0.295	14	1.19	7	2.83
35	0.417	12	1.41	6	3.36
28	0.589	10	1.68	5	4.00
20	0.883	9	2.00	4	4.76

(From Perry, Chemical Engineers Handbook).

A good specification for U.S. material is 90%, - 6 + 16 Tyler, which means that 90% should pass through a 3.36 mm opening and be retained on 1.00 mm.

When ordering granules it should be mentioned that all material be retained a smaller sieve (28 Tyler or 0.59 mm) thus preventing the presence of dust. It must however be kept in mind that transportation and unloading should be done with care; if not dust will be formed.

As mentioned European manufacturers generally produce granules of larger sizes. The advantages of larger granules are: they have a better crushing strength and when broadcasted in the field by mechanical means they give a more even distribution pattern.

But as a matter of fact the availability of uniform granules for all components to be blended is a more important factor.

IX-1.1. Speccifications

Consequently urea prills should not be used in bulk blends, unless it is sure that they have large size and that such a specification is mentioned in the order. As moreover prills have a lower crushing strength as compared with granules the better practice is to avoid the use of prills. It might be more difficult to purchase urea granules rather than prills. Therefore a good survey of the market is necessary (See Chap.IX-2)

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(The crushing strength of urea granules is 2 to 3 times as high as for urea prills; large granules are stronger than small ones). Urea should contain 45-46% N, its maximum moisture content should be 0.5%. For use under hot and wet climatic conditions coated urea should be used. This product has a better resistance towards caking than the uncoated product. The critical humidity of urea at 30°C = 75.2%; this figure should never be surpassed. In Chapter VII-Annex 2 this problem is discussed in details.

IX-1.2. Diammonium phosphate

DAP is available in well formed granules. Its critical humidity at 30°C is 82.8%. Conditioned product should preferably be ordered. Analysis may vary between 16-18% N and 46-48% P_2O_5; 18-46-0 is most frequently marketed. Maximum moisture content should be 2%.

IX-1.3 Triple superphosphate

TSP is available in well formed granules. Its relative humidity is 93.7% at 30°C. Analysis is 42 to 46% P_2O_5; maximum moisture content is 4.0%. It cannot be used in mixtures with urea or DAP (See Chapter IX-4). In our situation its use therefore is limited. There exists a product named ammoniated superphosphate which contains 2.4% of N. This product can be used in mixes with DAP and urea.

IX-1.4 Sulphate of ammonia

SA forms granular crystals of good and uniform size. It might be used where sulphur is needed from an agricultural point of view. It is nowadays a relatively cheap fertilizer as it is a byproduct of the manufacturing of caprolactam, an intermediate of nylon-6. Its critical humidity is 79.2% at 30°C. Analysis is 20 to 21%N; maximum moisture content is 1.0%.

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IX-1.5. **Potassium chloride**

This product is available in granular form made by compacting processes. Analysis is 60-62% K_2O; maximum moisture content is 0.5%. Its relative humidity is 84.0% at 30°C.

IX-1.6. **Potassium sulphate**

Some crops as tobacco, tomatoes ask for chlorine free fertilizers. In such cases potassium sulphate rather than potassium chloride is used. Potassium sulphate is available as compacted granules. Analysis is 50% K_2O; maximum moisture content is 0.5%. Its relative humidity is 96.3% at 30°C.

IX-1.7. **Fillers**

Fillers are inert materials that are used for two reasons, first to arrive for convenience sake at grades expressed in whole figures, avoiding the use of fractions (23-23-0 and not 23.3-23.4-0). Secondly to compensate for differences in analysis of the components and to ensure the production of standard grades.

Fillers should be used at a moderate degree. As they are inert materials transportation over long distances only adds to the costs. Any cheap and inert material can be used as a filler.

On this subject we had several discussions with the geologists of the Ministry of Mines. In the Assab area deposits of limestone, dolomite and of coral sands do exist.

Moreover Assab Salt Works could provide common salt, sieved at a convenient size. However we were informed that the Ethiopian soils generally do not endure even small amounts of common salt.

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Therefore salt cannot be used as a filler. In the opinion of the officials of the Ministry of Mines coral sands would be a convenient source of filler material. There are several deposits of coral sands and basaltic sands in the area; but they have to be investigated more carefully.

The granulometry of the deposits, their depths and accessibilities has to be investigated in detail. Plans to carry out such investigations are made and in due time the results will be forwarded to us. Most probably a coral sand deposit only has to be excavated and the proper sized granules have to be sieved out. Coral sands do contain small amounts of P_2O_5, however in an insoluble form. Therefore, this P_2O_5 content should not be considered when computing formulations (Chapter IX-3). About 6 to 13% of the amount of mixed fertilizers produced has to be filler. Average is about 10%. Production therefore has to be about 7000 tons in the first year and gradually will rise to about 20,000 tons. In case sand deposits are not available quarried limestone or similar minerals have to be used. This implies crushing and sieving equipment and investment costs will be considereable higher.

An amount of $300,000 is provided for activities of filler production (about $400,000 including erection, contingencies etc).

IX-2. <u>Sources of raw materials</u>

The products needed as raw materials are available all over the world. Nowadays there is a shortage of fertilizers, but there are signs that supplies will augment in the near future.

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The mixing plant will be operational at the end of 1976 or later. Therefore the market structure can then be different from the present situation. In view of the complicated situation it is strongly advised to keep in touch with the International Fertilizer Supply Scheme of F.A.O. in Rome and to place orders as early as possible.

Market situations and prices are regularly discussed in "Fertilizer International", a monthly paper published by the British Sulphur Corporation Ltd. London. It is recommended to subscribe to this monthly paper.

DAP is produced in W-Europe (Holland, U.K., France etc.), in N-Africa (Morocco, Tunisia, Algeria), in Jordan and in U.S.A. When the Suez Canal is opened the North African countries and Jordan are at short distance of Assab.

T.S.P. is produced in the same countries as DAP

Urea is produced in W.Europe (Holland, U.K. France, Italy etc), in Algeria, in the Persian Gulf area (Iran, Kuwait, Saudi Arabia, Qatar) and in U.S.A.

Sulphate of ammonia is produced in W-Europe, and in U.S.A. It is now mainly a byproduct of the Nylon Industry and the steel industry.

Potassium Salts. Main producers are Canada, France, W-Germany E-Germany, USSR, Spain, Israel, U.S.A. and Congo. A large plant is being constructed in Jordan at the Dead Sea that may be in production very soon.

IX-3. Formulations. EPID informed us that the most important ratios wanted for Ethiopian crops are: 1-1-0, 1-2-0, 1-1,5-0, 1-1-1 and 0-1-1. About 80% will be ratios 1-1-0 and 1-2-0. The different products can be made in the following ways.

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IX-3.1. **Ratio: 1-1-0**

Grade: 27-27-0

Urea 46:	356 kg	=	164 kg N
DAP 18-46:	587 kg	=	106 kg N + 270 kg P_2O_5
Filler:	57 kg	=	
	1000 kg	=	270 kg N + 270 kg P_2O_5

When using a lower grade of urea the calculation gives:-

Urea 45:	364 kg	=	164 kg N
DAP 18-46:	587 kg	=	106 kg N + 270 kg P_2O_5
Filler:	49 kg	=	
	1000 kg	=	270 kg N + 270 kg P_2O_5

In diminishing the amount of filler a lower grade of urea can be used to give the desired grade..

IX-3.2. **Ratio: 1-2-0**

Grade: 18-36-0

Urea 46:	85 kg	=	39 kg N
DAP 18-46:	783 kg	=	141 kg N + 360 kg P_2O_5
Filler:	132 kg		
	1000 kg	=	180 kg N + 360 kg P_2O_5

Ratio: 1-2-0

Grade: 19-38-0

Urea 46:	89 kg	=	41 kg N
DAP 18-46	826 kg	=	149 kg N + 380 kg P_2O_5
Filler	85 kg		
	1000 kg	=	190 kg N + 380 kg P_2O_5

IX-3.3. **Ratio: 1-1,5-0**

Grade: 22-33-0

Urea 46:	197 kg	=	91 kg N
DAP 18-46:	717 kg	=	129 kg N + 330 kg P_2O_5
Filler:	86 kg		
	1000 kg	=	220 kg N + 330 kg P_2O_5

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IX-3.4. Ratio: 1-1-1

Grade: 18-18-18

Urea 46:	239 kg = 110 kg N	
DAP 18-46	391 kg = 70 kg N + 180 kg P_2O_5	
KCL 60%	300 kg =	180 kg K_2O
Filler:	70	
	1000 kg = 180 kg N + 180 kg P_2O_5	+ 180 kg K_2O

IX-3.5. Ratio: 0-1-1

Grade: 0-24-24

TSP 42%:	571 kg = 240 kg P_2O_5		
KCL 60%:	400 kg		240 kg K_2O
Filler:	29 kg		
	1000 kg = 140 kg P_2O_5	+	240 kg K_2O

When using a higher grade of TSP the calculation gives:

TSP 46%:	522 kg = 240 kg P_2O_5		
KCL 60%:	400 kg =		240 kg K_2O
Filler:	78 kg		
	1000 kg = 240 kg P_2O_5	+	240 kg K_2O

In the practical production of mixed fertilizers these calculations have to be carried out considering the analysis of each different lot of raw materials.

IX-4. Compatibility of materials: Not all products can be mixed. In some cases reaction between the components cause caking or formation of semi-fluid and sticky products.

Some combinations of materials should be avoided. Handbooks on fertilizers give detailed information about these problems and contain compatibility charts which show which materials should not be mixed.

In our case the most important combinations to be avoided are:

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Urea and Superphosphate

Due to a reaction between urea and monocalciumphosphate-hydrate water is released and subsequently the mixture becomes sticky. When ammoniated superphosphate is used there are no problems.

DAP and Superphosphate

Ammonia from DAP can react with superphosphate and as a result water of hydration is released thus causing caking. When ammoniated superphosphate is used there are no problems.

Urea and Ammonium nitrate (or ammonium sulphate nitrate)

These two products should not be blended as the critical humidity of the mixture is only 18%, which means that under practically all circumstances the mixture becomes sticky in a very short time.

IX-5. Bags

Fertilizers used in Ethiopia up to now are imported packed in bags containing 50 kg. Bags used are woven propylene outer bags, with a separate polyethylene liner bag. The woven propylene bag is made out of extruded tapes, its weight is about 120-150 gr. The inner liner is made out of p.e. tubular foil of a thickness of 0.05-0.1 mm.

The liner is heatsealed and the outer bag is sewed. A 50 kg bag has dimensions of about 65 x 90 cm. These bags proved to be suited for the local situation of storage and transportation. The sealed inner liner is air-tight and impervious, whereas the woven outer bag is strong. The combination can withstand rough handling and storage conditions. Secondary and tertiary feeder roads are not always in a good condition and part of the transportation has to be done using mules and donkeys. Therefore a strong combination of woven bag plus liner is a necessity. The disadvantage of this combination is its high cost.

Therefore, if the conditions of roads are improved and the plans to perform this in the years to come are realised a cheaper type of bag could be envisaged.

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There is one disadvantage to the use of woven propylene. Apparently this material is sensitive to exposure to sunshine. It then detoriates and loses its strength. Jute bags have a better resistance to sunshine and have to be considered as a substitute for polypropylene woven bags.

IX-5.1. Alternative to these bags are:-

<u>Paper bags</u> made out of several layers of kraft paper, some of them treated with bitumen. Paper bags can be open mouth type or valve bags. Paper bags have poor resistance to rain and should not be used in this country.

<u>Plastic valve bags</u>
These bags are made out of foils (p.e) and have to be filled on special machines. They are not to be considered as suitable for this country as the valve is not entirely watertight.

<u>Plastic open mouth bags</u>
Made out of tubular foil 0.2-0.4 mm thick, material should be polyethylene. These bags are also made out of polyvinyl chloride but the p.e. bags are to be preferred as p.v.c. is brittle below 3°C, its water vapour permeability is high and it stretches at high temperatures. The open mouth bag has to be heatsealed. Small ventholes of 0.2 mm have to be present in order to allow excess air to escape. This is a very good and cheap type of bag. Its strength is good, though not as good as a woven bag with liner. As soon as road and distribution conditions are improved the use of this type of bags should be considered. In W/Europe this type of bag is extensively used and has proved to be able to withstand transportation by trucks and ships.

<u>Bags made out of natural fibres</u>
Alternatives to woven polypropylene bags are those made out of jute, sisal and other local fibres. These bags are produced in the country. Costs are mentioned to be $0.90 plus 4% taxes = $1.00. Jute and similar bags have a considerable second hand

value and farmers can use them for transportation of crops and other products. They are considered to be more useful than polypropylene bags. Plans do exist to produce polypropylene bags in Ethiopia. The inner liner bags can be produced in the country. Recently modern equipment is installed and there are no problems to purchase them in due time. Costs are mentioned to be $0.20.

At a volume of 100,000 tons of fertilizer 2,000,000 bags and liners are needed. The outer bags should be printed to carry the company's name as well as the grade of the fertilizer.

CHAPTER X
MANPOWER

X- 1. Manpower to run the factory and the handling facilities is composed of two groups.

X- 1.1. The first group is used for the unloading of ships at Assab-Harbour. This has to be performed by personnel of the Port-Authority, that have to be paid according to the time spent on unloading. We were informed that wages are: labourers $1.33 per hour, foreman $1.13 and clerk $1.75 per hour. For unloading activities are needed 12 labourers, 1 foreman and 1 clerk. Hourly wages amount thus to $19.34 per hour or $464.16 per 24 hours (Chapter VI-2.2.0). Assuming that 100,000 tons to be unloaded in 1500 hours costs are $29,010.

X- 1.2. The second group of personnel is on the company's paylist. There are two subgroups, one that is working in a day shift continuously during the year or season and another that works on a three shift basis and whose task is to transport the unloaded materials from the harbour to the factory and into the raw material storage. This group is only working if ships have to be unloaded in Assab-Harbour or filler material is to be transported.

X-1.2.1. The permanent group of personnel consists of:-

1 Manager
1 Accountant
1 Laboratory Technician
1 Storekeeper
5 Foreman (3 at store, 1 at the processing units
1 at the bag storage and delivery)
3 maintenance workers of which 1 Electrician and
2 Mechanics
4 Guards (working in 3 shifts)
2 Wheelloader drivers
54 Labourers
In total 72 persons ..

The 54 labourers are distributed as follows:- (See Chap.VII)

Mixing plant	3
Bagging plant	12
Storage and delivery of bags	37
Laboratory (assisting the technician)	1
Canteen	1

Wages or these labourers are $150 per month.

Total wages of 54 labourers amount to $97,200 per year. One foreman in the mixing and bagging units and one in the bag storage will be in charge of daily operations.

For transportation from harbour to the factory and into the raw materials 3 foremen are needed as this work has to be performed in a 3 shifts service. At a volume of 100,000 tons 1500 hours are needed (See Chapter VI-2.2.1). This corresponds to 63 days, which implies that for a greater part of the year there is only a limited task for these 3 foremen. Now one of them can at the same time be in charge of the transportation of materials to the processing units, a task that has to be carried with utmost care. The second foreman of this group could be in charge of the production of fillers (See Chapter X-1.2.2). But at present no definite setup can be made as to these operations. To be able to do so detailed informations from the geologists of the Ministry of Mines have to be received. It has to be investigated whether the third foreman could be an assistant to the laboratory technician. Salaries of foremen are $200 for those working in the storage and $250 for the foreman in the mixing and bagging plant. Total salaries amount $12,600 per year.

Training of foremen and of operators in the factory should be done by the expatriate supervisors during plant erection. The 4 guards work in 4 shifts. Their tasks is supervision of in and outgoing persons and vehicles, operation of the truck weigher and of the fuel station for diesel fuel as well as to provide administrative data about this activities that can be processed at the office. Wages are $150 per month Total wages are $7,200/year.

The three technicians (one electrician and two mechanics and fitters) should earn $500 a month. Total wages are $18,000 per year. They should be trained during the erection activities by the expatriate supervisors.

One of the payloaders drivers has a permanent job, the other is only needed under extreme conditions (Chapter VII-1.1.3.4). Work should be arranged in such a way that in idle hours one of the drivers should do maintenance work on trucks etc. Possibly one payloader or a similar machine is needed at filler quarry. One of the drivers could operate that machine but in such cases he is not available for stand-by activities in the storage. Training of wheelloader drivers should be given by the importer. Wages are $350/month. Total is $8,400/year.

The storekeeper should keep records of all incoming, outgoing and stored materials as raw materials, empty and filled bags, fuel, spare parts etc. He should be in touch with the clerk from Assab Port Authority who makes records of unloaded materials. An experienced man should be nominated for this job. Wages are $300 per month or $3,600 per year.

Three office clerks are in charge of the different tasks in a factory office under supervision of the accountant. Among others their tasks include administration of stocks, calculation of wages, production costs, preparation of invoices etc. Wages are $500/month, totalling to $18,000/year.

The Accountant is responsible for all administrative activities. He should advise the manager and prepare reports about the course of events in the factory. He should have ample experience in the administrative activities of a factory. Salary is $12,000/per year.

The laboratory technician is in charge of the analytical control of incoming raw materials and bags, of the results of the mixing operations and of the outgoing fertilizers. He is responsible for accurate sampling. In case of deviations from specifications he should take action without delay.

He should report to the manager on a daily basis. Preferably a technician experienced in fertilizer analysis should be nominated. If such an employee is not available an in-plant training in a well equipped laboratory specialized in fertilizers is necessary. Duration of the training should be 3 to 6 months depending on previous experiences. Salary is $600/month or $8,400 per year.

The factory manager should have experience in the chemical or processing industry and of the overall problems of management. General knowledge of fertilizer technology should be welcome and a training period within industry is necessary. Knowledge of maintenance procedures, more specifically of preventive maintenance systems, is necessary. Techno-economical insight and a business like attitude are welcome qualities. Salary is assumed to be $18,000/year.

X-1.2.2. The group of personnel in charge of the transportation of raw materials (assuming a volume of 100,000 tons) works for 1500 hrs per year in 3 shifts. Therefore each worker is active for 500 hours per year or 63 days (See Chap. VI-2.2) which is about 17% of a full task.

The group consists of 21 truck drivers and of 9 labourers at the factory site. These 9 labourers are operating the conveying system to transport raw materials brought in by the trucks into the storage.

The tasks of the three foreman supervising these operations is discussed in Chapter X-1.2.1. They should be permanently employed. As to the 21 truck drivers and 9 labourers there is a difficult situation. The total strength of the daily employed group of labourers is 54. It is not possible to add to or to draw off a group of 30 man from the permanent group of 54. At the best this could be done for the 9 man operating the conveying system. However for 21 drivers there is no place under normal circumstances.

However there is one transportation task that can be performed by part of the group of 21 drivers namely the transportation of filler material to the factory. At present nothing is known about the definite site nor about the nature of the deposits to be processed (Chapter VIII-4). Moreover for transportation on the quarry site itself from the pit to the screening section tipping trucks could be used. Even if all the trucks are used in these activities only 7 of the 21 drivers could be used on the trucks as work on the quarry is only done at daytime. Moreover only 5000 ton of filler have to be produced in the first year. (This amount is gradually rising to 13,000 ton in 1980). Therefore a limited number of days of quarrying, screening and transportation activities are necessary and the quarry activities can be interrupted during the days ships are to be unloaded. Exact calculations can only be made if full details are known about the nature and the site of the deposits. It should be investigated to employ all the drivers in the quarry.

In our calculations of the operating costs in Chapter XI the activities of this group of personnel are considered only for their active labour being 1500 hours per year at a volume of 100,000 ton. (As mentioned each individual worker is active for 500 hours). The salary costs are presented here both on a basis of 1500 hours and on a years basis. Assuming a drivers salary to be $300/month the hourly wages are $1.40 (1 month = 215 hrs). The labourers earn $150/month or $0.70 per hour. Therefore when this personnel is paid on the basis of 500 hr costs are:-

21 drivers, 500 hours at $1.40 =		$ 14,700
9 labourers, 500 hours at $0.70 =		3,150
	Total	$ 17,850

When paid on the basis of one year costs are:-

21 drivers at $300/month =		75,600
9 labourers at $150/month =		16,200
	Total	$ 91,800

The difference is considerable, however this group will be employed in a year's basis.

X-1.2.4. Summary

Table X-1 presents a summary of the personnel needed:-

	Labourers	Craftsman drivers	Foreman	Clerks	Technician	Accountant	Manager	Total
Unloading in Harbour by personnel of Port-Authority	12		1	1				14
Transportation to storage 1500 hr/year	9	21	3					
Sub-total A	9	21	3					33
Personnel in continuous service								
processing	15	2	1	-				18
handling of bags	37	-	1	-				38
office	1	-	-	4	-	1	1	7
workshop	-	3	-	-	-	-	-	3
laboratory	1	-	-	-	1	-	-	2
guards	4	-	-	-	-	-	-	3
Sub-total B	58	5	2	4	1	1	1	72
Total A + B	67	26	5	4	1	1	1	105

Total labour costs for personnel on the factory's paylist on a year's basis are:-

A.	54 labourers	$ 97,200
	5 foremen	12,600
	4 guards	7,200
	3 maintenance technicians	8,000
	2 payloader driver	8,400
	1 store-keeper	3,600
	3 office clerks	18,000
	1 accountant	12,000
	1 laboratory technicians	8,400
	1 manager	18,000
	miscellaneous	6,000
	Total	$209,400

B. The labour costs for the personnel in charge of the transportation of raw materials from the harbour to the storage when paid on a year's basis are: $91,800

C. The labour costs for unloading ships that have to be paid to the Port Authority amount to $19.34 per hour. At a basis of 1500 hours conveyor including with a volume of 100,000 tons Costs are $29,010.

A.	Personnel on a year's basis	$ 209,400
B.	Personnel for transportation	91,800
C.	Personnel from Port Authority	29,010
	Total	$330,210

X-3. Accommodations

In the long run housing provisions near the plant should be considered for plant operators and other substantive personnel. For the time being employees are expected to provide their own accommodation in town. The company must provide a medium sized bus.

CHAPTER XI

Financial Assessments

XI-0 **Introduction**

In this chapter the following items will be treated:-

Capital costs

Operating costs

Overheads

Alternative costs of import of baggod and bulk fertiliser

Working capital

XI-1 **Capital Costs**

To be considered are the capital costs of:-

i. Equipment for unloading of ships and for transportation to the factory.

ii. Equipment needed for processing and for transportation within the factory.

iii. Costs of buildings

iv. Costs of auxiliaries and utilities

XI-1.1.0 In Chapter VI-2.1 the equipment to be used when unloading at Assab Harbour is discussed. The costs are:-

3 grabs fob		$ 58,800
freights		5,200
3 hoppers		30,000
		$ 94,000
	Contingencies 10%	9,500
		$103,500

This equipment is to be operated by personnel of Assab Port Authorities.

For transportations to the factory 8 tipping trucks are foreseen (Chapter VI-2.13), including spare parts.

Costs are	$ 480,000 or
when including 10% contingencies	$ 528,000
After 200,000 km. the salvage value is	$ 10,000/truck
This type of unloading and transport is limited to a volume of	290,000 t/year.

XI-1.1.1 The factory jetty has to be operational in 1978/79. When unloading at a factory jetty equipped with harbour cranes two situations are considered (See Chapter VI-3.0)

i. One crane is used. In this case the maximum capacity is 480,000 tons/year. This volume is reached in 1981/82.

ii. Two cranes are used from 1982/83 on.
The harbour cranes are movable on rails and discharge each into a movable hopper. Transportation into the storage is done by a belt conveyor system.

Investments costs to be spent in 1978 (on basis of prices 1974).

1 harbour crane	$ 450,000
2 grabs	66,000
1 hopper	40,000
mails	10,000
belt conveyor	700,000
	$1,266,000
freight, insurance 15% port clearing 8% = 23%	291,000
	$1,557,000
erection and supervision 12%	186,800
	$1,743,800
interest during construction 10%	174,400
	$1,918,200
contingencies 15%	287,700
Total	$2,205,900

In 1982 extra investments are

1 harbour crane	$ 450,000
1 hopper	40,000
1 grab	33,000
	$ 523,000
freight, insurance, port clearing & handling 23%	120,300
	$ 643,300
erection and supervision 10%	64,300
	$ 707,600
interest during construction 10%	70,800
	$ 778,400
contingencies 15%	116,800
Total	$ 895,200

XI-1.2. Building and equipment needed for processing and transportation within the factory consists of:-

i. building and equipment to bring raw materials into the storage.

ii. equipment to transport raw materials to the mixing and bagging units

iii. mixing plant including building

iv. bagging plant including building

v. building and equipment for storage and handling of bags

vi. truck weigher

XI-1.2.1. The storage building for raw materials (Chapter VII-1.1.)

is calculated to cost		$ 486,000
The equipment contains an underground hopper + feeder		20,000
bucket elevator		160,000
belt conveyor		80,000
tipping-off carriage		22,000
	f.o.b.	$ 282,000
freight, insurance 15%		
port clearing, handling 8% = 23%		64,860
		$ 346,860
erection and supervision 12%		41,640
		$ 388,500
contingencies 15%		58,300
		$ 446,800
interest capital during construction 10%		44,700
		$ 491,500
expatriate supervision 2 man-month at $7250 (U$3500)		14,500
	Total	$ 506,000

XI-1.2.2. Equipment to transport raw material to the processing units consists of two wheelloaders at a cost of $84,000 each, delivered at factory site

Total investments $ 168,000

XI-1.2.3. The mixing unit is described in Chapter VII-1.1.4 investment costs are:-

1 hopper + discharge belt	$ 9,000
1 bucket elevator (80 t/hr)	90,000
1 screen	50,000
1 lumpbreaker	10,000
1 hopper + swivel spout	5,000
1 four-compartment hopper	16,000
1 batch weigher	10,000
1 mixer	50,000
1 holding hopper + discharge belt	18,000
f.o.b. price	$ 258,000
freight, insurance, port clearing & handling 23%	59,340
	$ 317,340
erection etc. 12.5%	39,660
	$ 357,000
contingencies 15%	53,600
	$ 410,600
interest during construction 10%	41,400
4 man-month expatriate supervision at $7250	29,000
	$ 481,000
The costs of the building (VII-1.1.5.2.) are	$ 70,[illegible]00

XI-1.2.4. The bagging plant is described in VII-1.1.5.1. Investments costs are:-

	Qty.	
Hopper and discharge facility	1	$ 10,000
bucket elevator (80 t/hr)	2	160,000
double deck screen	2	130,000
lump breaker	2	20,000
feed hopper for weigher	2	10,000
duplex weigher including filling spout and electrical control equipment	2	90,000
slat conveyor	2	16,000
heat sealer	2	50,000
sewing machine	2	16,000
ventilation	2	6,000
air compressor	1	2,000
	fob.	$ 510,000

freight insurance 15% + port clearing, handling 8% = 23%		$ 117,300
		$ 627,300
erection etc. 12.5%		78,400
		$ 705,700
contingencies 15%		105,900
		$ 811,600
interest during construction 10%		81,200
6 man-month expatriate supervision at $7250 =		43,500
	Total	$ 936,300

The costs of the building (VII-1.1.5.2) are $ 70,000

1.2.5. In Chapter VII-Annex 5. several types of transportation and handling of bags were discussed. It was shown that manual transportation and use of mechanical piling equipment was to be preferred. Investments costs are:-

Building (Chapter VII-1.1.1.6) $ 325,000

The equipment needed is described as well in Chapter VII-Annex V. Investment costs are:-

	Qty.		
wheel barrows	40		$ 2,400
movable belt conveyor for piling	2		50,000
			$ 52,400
contingencies 15%			7,900
		Total	$ 60,300

XII-1.2.6. To weigh in and outgoing materials as well as outgoing bagged fertilizers a truck weigher is needed:

Investment costs are:

1 truck weigher f.o.b.	$	15,000
freight, insurance, port handling and clearing 23%		3,500
erection etc. 12.5%	$	10,500
		2,300
contingencies 15%		20,800
		3,100
Total		23,900

XI-1.3. __Utilities and auxiliary services__ are discussed in Chapter VIII.

The investments for these services are:-

Water supply	25,000
Power-station	100,000
Workshop, building	72,000
Workshop, equipment	32,000
Facilities for filler production	300,000
Office building	60,000
Office equipment etc.	24,000
Canteen equipment	8,400
First aid room equipment	5,000
Laboratory equipment	19,500
Instruments in storage	5,700
Roads, fencing, parking area & gardening	198,000
Total	$ 849,600

XI-1.4. __Summary of investments__

Unloading equipment	103,500
Trucks	528,000
Storage building	486,000
Equipment storage building	506,000
Wheelloaders	168,000
Mixing uhit, building	70,000
Mixing unit, equipment	481,000
Bagging unit, building	70,000
Bagging unit, equipment	936,300

Storage for bags	$ 325,000
Equipment for handling of bags	60,300
Truck weigher	23,900
Utilities and auxiliary services	849,600
Pre-operation expenses etc.	592,400
	$5,200,000

Operating costs

The operating costs to be considered are those of:

(i) unloading of ships
(ii) transportation by trucks
(iii) conveying into storage
(iv) conveying to processing units
(v) mixing
(vi) bagging
(vii) handling of bags including loading on trucks
(viii) weighing of trucks

Costs of transportation from factory to storages in the country are not considered. Bagged fertilizers are delivered at the factory gate.

It was not possible to make a calculation of the operating costs of the filler production as at present little is known about deposits and about their processing. As soon as details about filler production are available (Chapter IX-1.7, X-1.2.2) studies about equipment, transportation etc. should be made.

For the time being the costs of filler are estimated to be $10 per ton.

XI-2.1. Operating costs of unloading ships. At the harbour site the ship's gear is used with the company's grabs and hoppers. Operating costs contain capital costs and maintenance of equipment as well as labour costs. Labour has to be provided from Port Authorities and is not on the companies paylist. Wages are averaged for day and night shifts: Foreman $1.63, Clerk $1.75, labourers $1.33 per hour. Per hold are needed: 3 man + 1 winch operator (if not provided by the ship's crew) and on the quai 1 man on the top and 1 man at the discharge of the hopper. Two holds are discharged simultaneously. One foreman and one clerk have to be added. So total labour is:-

12 at $1.33	=		$ 15.06/hour
1 at $1.63	=		1.63/ "
1 at $1.75	=		1.75/ "
		Total	19.34/hr. or
			$ 464.16/per day (24 hr.)

Capacity is 1760 tons per day, so the wages component in unloading costs is $0.264 per ton.

Investments costs (Chapter XI-1.1.0) are $103,500

Yearly fixed costs are:

Interest on capital 10%	10,350
Depreciation 10%	10,350
Insurance 2%	2,070
Maintenance 3%	3,150
Total fixed costs	$ 25,920

Total costs for unloading

100,000 t/year are $26,400 + $25,920 = $ 52,320 or $0.52/ton
150,000 t/year are $39,600 + $25,920 = 65,520 or $0.44/ton
200,000 t/year are $52,800 + $25,920 = 78,720 or $0.39/ton
290,000 t/year are $76,560 + $25,920 = 102,480 or $0.35/ton

XI-2.2. Operating costs of truck transportation

A fleet of 8 trucks (Chapter VI-2.1.3) is needed to meet the unloading rate at Assab Harbour. To operate seven trucks on a three shift basis 21 drivers are required. The rate of transportation is 80 tons per hour. On the basis of drivers wages of $300/month and including 20% of idle time the break down of costs comes to $0.147/ton or $0.11/km ($300/month = $1.40 per hour. 100,000 ton or 134,000 km takes 1500 hour. Total costs $14,700). The drivers will only be occupied for their normal duties for 1500 hrs. or 62 days to transport the 100,000 tons mentioned. See Chapter X-1.2.2. Other variable costs factors related to trucks are depreciation, fuel, tyres and maintenance. One truck costs $60,000 including spare parts. On the assumption of a savage value of $10,000 after 200,000 km. depreciation comes to $0.25/km. Diesel fuel consumption is calculated to cost $0.12/km (1 lt. to 3 km.) With tyres, maintenance and miscellaneous costs taken as $0.04, $0.06 and $0.03 respectively, the following costs per km. are arrived at:-

drivers wages	$0.11
depreciation	0.25
fuel	0.12
maintenance	0.06
tyres	0.04
miscellaneous	0.03
variable costs	$0.61/km or $0.817/ton

For the 134,000 km distance or 100,000 tons total haulage, the variable costs stand at $81,740. Fixed costs are charged to interest on capital and to insurance. The wages of 3 foremen supervising truck transportation and conveying into the storage are imputed for 50% to transportation (See Chapter VII). Insurance and interest are calculated at 5% and 10% of the investments costs respectively. No allocation to road taxes is included. Investments costs are $528,000 (See Chapter XI-1.1.0).

Fixed costs are:

Interest on capital 10%	$ 52,800
Insurance 5%	26,400
50% of wages of 3 foremen	3,600
	$ 82,800

Table XI-1 Transportation costs

Imports Distance travelled	100,000 ton 134,000 km	150,000 ton 201,000 ton	200,000 t 268,000 km	290,000 t 389,000 km
Fixed costs	$ 82,800	$ 82,800	$ 82,800	$ 82,800
Variable costs	$ 81,740	$122,610	$163,480	$237,200
Total costs	$164,540	$205,410	$246,280	$320,000
Costs per ton	$1.65	$1.37	$1.23	$1.10
Costs per km	$1.23	$1.02	$0.92	$0.82

Total costs and costs per ton for unloading and transportation to the factory are:-

Table XI-2

	100,000 ton	250,000 ton	200,000 t	290,000 t
Unloading	$ 52,320	$65,520	$ 78,720	$102,480
Transportation	$164,540	$205,410	$246,280	$320,000
Total	$216,860	$270,930	$325,000	$422,480
Cost per ton	$2.17	1.81	$1.63	$1.46

XI-2.3. **Operating costs of conveying raw materials into the storage**

Investments costs (XI-1.2.1) are:-

Building	$486,000
Equipment	506,000
	$992,000

The installed power is 47 HP = 35 KW.
Three labourers are needed per shift; two at the discharge of the tipping trucks and one to operate the tipping-off device of the beltconveyor. The tasks of the three foremen are discussed in Chapter X-1.2.1. 50% of the wages of the foremen shall be imputed to this entry (See Chapter XI-2.2). Three shifts of three man and 1500 hours are needed to transport 100,000 ton. This amounts to 4,500 man-hours plus 50% of the activities of 3 foreman (at $200/month).

Fixed costs are:

Interest 10%	$ 99,000
Depreciation building 5%	24,300
Depreciation equipment 10%	50,600
Insurance 2%	19,840
Maintenance building 1%	4,860
Maintenance equipment 3%	15,180
	$213,900

Variable costs for 100,000 ton are:

50% of wages of 3 foremen at $200/month	$ 3,600
Wages 4,500 hours at $1.33	5,985
Energy 35 x 1500 = 52,500 KWH at $0.08	4,200
Total	13,785
or per ton	$0.14

Table XI-3 presents the operating costs at various volumes.

Table XI-3

	100,000 t	50,000 t	200,000 t	290,000 t
Fixed costs	$213,900	$213,900	$213,900	$213,900
Fixed costs per ton	$2.14	$1.43	$1.07	$0.74
Variable costs per ton	$0.14	$0.14	$0.14	$0.14
Total costs per ton	$2.28	$1.57	$1.21	$0.88

XI-2.4. Transportation to processing units

In this case transportation using payloaders is considered.

Investment costs are (XI-1.2.)	$168,000
Two wheelloader drivers are needed	
Operating costs are:	
Interest 10%	$ 16,800
Depreciation 10%	$ 16,800
Insurance 5%	$ 8,400
Fuel	$ 15,000
Tyres 4%	$ 6,700
Maintenance 6%	$ 10,800
Wages 2 drivers at $350/month	$ 8,400
	$ 82,900

At a volume of 100,000 tons/year (220 days) operating costs are $0.83/ton and at 200,000 tons in 330 days and consuming $7,500 extra fuel $0.45/ton

XI-2.5. Operating costs of mixing plant

Investments are $481,000 for equipment plus $70,000 for the building (XI-1.2.3.). The mixing plant has to be operated by 3 labourers; one at the receiving hopper, one at the discharge of the screen whose task is the operation of the swivel spout and the attendance of the cummunication system. The third operator is in charge of the batch weigher and of the operation cycle of the mixer.

A foreman supervises mixing as well as bagging operations. As the latter activities have a large volume his wages are imputed to the bagging costs. Total energy is 41 KW (VII-1.1.4)

Operation costs when run with one shift are:-	
Interest on capital 10%	$ 55,100
Depreciation of building 5%	$ 3,500
Depreciation of equipment 10%	$ 48,100
Insurance 2%	$ 11,020
Maintenance building 1%	$ 700
Maintenance equipment 3%	$ 14,430
Wages 3 labourers at $150/month	$ 5,400
Energy 41 KW during 7 hr. 330 days at $0.08	$ 8,860
	$147,110

At a volume of 50,000 tons per year of mixes (100,000 total production including straights) costs per ton are $2.94

At a volume of 100,000 tons of mixes (2 shifts; extra wages + energy $14,620) $1.61

XI-2.6. Operating costs of bagging plant

Investments costs are $936,300 for equipment and $70,000 for the building (XI-1.24)

The bagging plant is operated by 12 labourers and one foreman with technical knowledge. Installed power is 35 KW

Operating costs are:

Interest on capital 10%	$100,630
Depreciation, building 5%	3,500
Depreciation, equipment 10%	93,630
Insurance 2%	20,130
Maintenance, building 1%	700
Maintenance, equipment 4%	37,450
Wages 12 labourers at $150/month	21,600
Wages foreman at $250/month	3,000
Energy 35 KW during 8 hr. 330 days at $0.08	7,390
Total	$288,030

At a volume of 100,000 per year of: bagged fertilizer costs per ton are:	$2.88
At a volume of 200,000 tons (2 shifts; extra wages + energy $31,990)	$1.60

XI-2.7. Operation costs of bag storage and handling

In Chapter VII - Annex 5 details are given about transportation of bags to storage and of loading in trucks. It was shown that a combined use of manual labour and piling equipment is the best choice.

Investments are (XII-1.2.5): building $325,000; equipment $60,300 of which $57,500 mechanical equipment and $2,800 wheelbarrows. Labour consists of 40 labourers and 1 foreman. Energy consumption is 15 KW.

Operating costs are:-

Interest on investments 10%	$ 38,530
Depreciation, building 5%	16,250
Depreciation, equipment 10%	5,750
Depreciation, equipment 20%	560
Insurance 2%	7,700
Maintenance, building 1%	3,250
Maintenance, equipment 3%	1,810
Electricity 15 KW during 8 hr. 330 days at $0.08	2,110
Wages 40 labourers at $150/month	72,000
Wages 1 foreman at $200/month	2,400
Total	$144,960

When 100,000 tons are handled costs are $1.50 per ton. When volume is 200,000 two shifts are needed. Extra costs for wages + energy are $74,400. Costs per ton are $1.10.

XI-2.8. Operating costs of truck weigher

Investment costs are $23,900 (XI-1.2.6)

No extra personnel is needed to operate the weigher. The gatekeeper can do this work. Operating costs are:-

Interest on capital 10%		$2,390
Depreciation 10%		2,390
Insurance 2%		480
Maintenance 3%		720
	Total	$5,980
For 100,000 tons costs per ton are		$0.06
For 200,000 tons costs per ton are		$0.03

(Because as well in-and outgoing material is weighed the double volume passes the weigher. However costs are imputed to outgoing products for the sake of simplicity.

XI-2.9. Summary

Costs for investments and operation of handling and storage of raw materials, of mixing and bagging units and of storage and handling of bagged products are summarized in table XI-4.

Table XI-4

	Operating costs per ton	
	100,000 ton/year	200,000/ton
Unloading of ships	$0.52	$0.39
Truck transport	1.66	1.23
Storage in	2.28	1.21
Storage out	0.83	0.45
Mixing operations (50% of volume)	2.94	1.61
Bagging operations	2.88	1.60
Bag handling and storage	1.50	1.10
Truck weigher	0.06	0.03
	$12.67	$7.62

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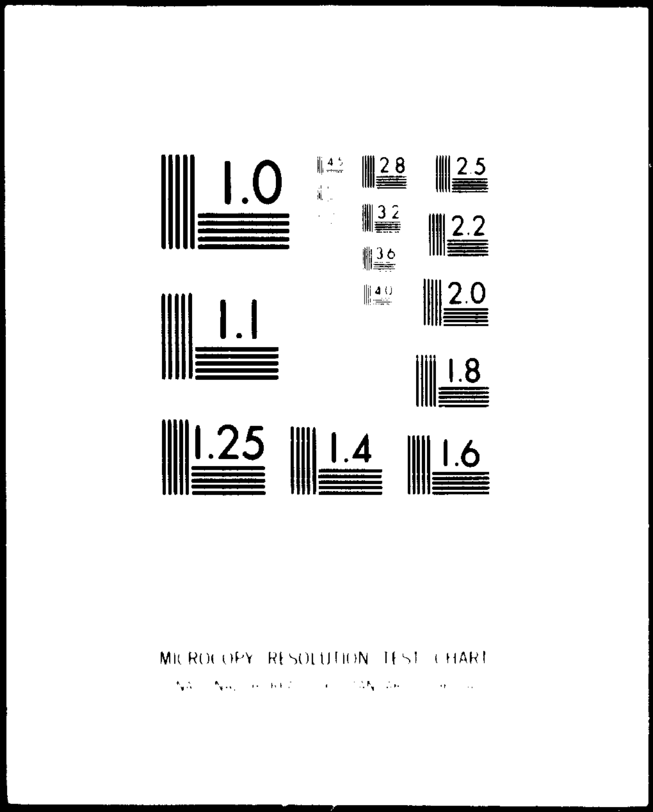

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XI-2.10. <u>Fillers</u>

Operational costs for filler could not be made as very little is known about their production. A cost price of $10 per ton is assumed in our further calculation.

XI-3. <u>Overheads</u>

Overheads contain costs of management, administration, laboratory, utilities. These costs are composed of:-

(i) interest on investments
(ii) depreciation
(iii) insurance
(iv) maintenance
(v) salaries
(vi) energy
(vii) stationery, chemicals etc.

Chapter XI-1.3 gives a survey of the fdifferent items. As maintenance of the factory is already calculated in the operating costs and as filler production is not to be considered (XI-2.10), the total investments to be considered are $445,600.

Of this sum $258,000 are for building and civilworks and $187,600 for equipment.
Salaries to be considered are those the manager, laboratory technician and assistant, accountant, office clerks, storekeeper, guards and a canteen waiter (See Chapter X-1.2.4.).
These salaries amount to $75,000

Energy will be 10% (5% losses in power station, 5% for lighting) of total installed power of 126 KW, so say 13 KW. Costs of stationery, chemicals for the laboratory etc. are estimated to be $10,000 per year.

Overhead costs are:

Interest on investments 10%	$ 44,560
Depreciation of building etc. 5%	12,900
Depreciation of equipment 10%	18,760
Insurance 2%	8,910
Maintenance of equipment 3%	5,630
Maintenance of building 1%	2,580
Salaries	75,000
Energy 13 KW during 8 hrs 365 days at $0.08	3,040
Materials	10,000
Miscellaneous (travel, communications)	2,000
	$183,380

XI-4. Alternative costs of production of bags vs. import of bagged fertilizer

XI-4.1. Fertilizer prices

For the season 1974/75 fertilizers are imported in Ethiopia. Part of the fertilizers obtained were supplied at reduced prices through F.A.O., part were purchased at world market prices. EPID informed us that prices for bagged products are:-

DAP (13850 ton), cif Assab, E$958.06/mt from U.S.A., March 1975
Urea (3000 ton), cif Assab, E$958.50/mt from Kuwait, December 1974
Urea (2500 ton), cif Assab, E$869.00/mt from Italy, March 1975
20-20-0 (8000 ton) cif Assab, E$663.87/mt from Germany, Jan/March/1975
BASF informed us that the price of Sulphate of Ammonia (SA) in bags cif Assab is DM525 = E$402/mt and that of
15 - 15 - 15 (NPK) in bags cif Assab is DM 742.50 = E$569.

The difference in prices cif Assab of bagged against bulk fertilizer is composed of 1. cost of bags
2. cheaper freight costs for bulk product.

It is supposed that costs of bags are E$1.20 or E$24/per ton.

Freight costs vary considerably as they depend largely on supply and demand of shipments.

AIMS informed us that in the middle of 1974 freight costs USA (Gulf Area) to Assab were US$67 and US$50 respectively for bagged and bulk fertilizers. The difference is US$17 or about E$35.-. Including savings on bags total savings are E$59 per mt. However it has to be kept in mind that the current high freight costs might go down. Assuming a difference for freight of bagged and bulk fertilizers of US$10 or E$21, total savings including bags might be E$45/mt.

XI-4.2. Import of bagged fertilizers as bagging and mixing at Assab

Calculations were made based on the raw material prices mentioned above. A saving of US$17 on freight costs was assumed. In this way we arrive at the following prices in round figures. Urea E$915/ton, DAP E$825/ton, SAE$360/ton.

It is supposed that the small amounts of NPK needed (350t/y) does not justify importation of the needed quantity of pottasium salts (53 t). Therefore for the time being NPK's shall be imported in bags. Demand projections for the year 1976/77 were used.

In the case of bulk handling, mixing and bagging in Assab factory overheads of $183,380 were added. In the case of unloading of bagged fertilizers overheads were estimated to be $30,000, being salaries for 1 accountant ($12,000), 2 clerks ($12,000), office rent $3,000 and miscellaneous ($3,000).

Plant expenses are based on data in table XI-4. Excluding bulk handling activities costs are $1,049 per ton at a basis of 100,000 ton; at a basis of 113,000 ton plant expenses are $9.98/t.

Bulk handling expenses are (XI-2.1. and 2.2):
fixed costs $82,800 + $25,920 = $108,720;
variable costs $0.264 + $0.817 = $1.081/ton
An amount of $2.60/ton, as was provided by A.I.M.S., is used for the costs of unloading of bagged fertilizer. The results of these calculations are presented in table XI-5.

The conclusion is that there are substantial profits in bulk handling, even when no extra profits for mixing and bagging are foreseen.

Profits on basis of the volumes to be handled in 1976/77 are $9.35 million.

Table XI-5

Quantity	Unit Price cif $	A. Bagged fertilizers $	B. Bulk fertilizers $
DAP 72,740 ton (Jan./March 1975)	958.00	69,684,920	
	915.00		66,557,100
Urea (March 1975) 28,910 ton	869.00	25,122,790	
	825.00		23,850,750
SA (March 1975) 2,600 ton	402.00	1,045,200	
	360.00		936,000
NPK 15:15:15 in bags 350 ton	570.00	199,500	199,500
	Unit Costs		
104,500 ton		96,052,410	90,407,850
Unloading costs	2.60	271,700	-
Overheads		30,000	183,380
Bags 2.3 million	1.20	-	2,760,000
Filler 8,380 ton	10.00	-	83,800
Plant expenses 112,880 ton	9.98	-	1,126,540
Bulk handling			
fixed costs	-	-	108,720
variable costs	1.081	-	112,970
104,500 ton fertilizer		96,354,110	
112,880 ton fertilizer			94,738,260
Average costs per ton in bags		(922.10)	(839.60)
112,880 ton	922.10	-	104,086,650
Difference/profit			9,348,390

XI-5. Working Capital

AID Bank made calculations on the working capital requirements for the periods 1976/77 up to 1980/81. Assumptions were:

10% of invested capital are imputed to spare parts, resulting in total equipment costs of $2,420,000; 30% of bulk storage is always occupied, 20% of bagged storage is always occupied. A quantity of bags sufficient for two months' operation is presented

A quantity of filler material for one month operation.

A quantity of fuel for two weeks operation.

One month of operating costs

Results were that working capital requirements are:

1976/77	$7,081,000
1977/78	$6,806,600
1978/79	$7,014,300
1979/80	$7,203,800
1980/81	$7,420,400

XI-6. The Research Department of AID Bank - using the Bank's computer - made some economical evaluations about the project.

Based on a period of one year of design and construction and of five years of production the Net Present Worth at a rate of 10% was calculated to be $5,201,000.

The Internal Return Rate turned out to be 24.2%.

CHAPTER XII

T E N D E R S

General

XII - 1. Preliminary proposals were asked for different sections of the bulk handling, mixing and bagging plants. For the main parts, quotations were asked to the following firms:-

1. Mitsibushi (Japan)
2. Nissho-Iwai (Japan) X
3. Basse Sanbre-Eri (Belgium)
4. Sybetra (Belguim)
5. Leco, Kentucky (USA)
6. Fertilizer Engineering Equipment Cy, Wisconsion (USA) X
7. Chartin Construction Ltd. (Associated to Longhorn Cy) USA X
8. Voest, Linz (Austria)
9. Screening and Application Engineering Ltd. (U.K.)
10. Alvan Blanch Development Ltd. (U.K.)
11. Greif Werk (W/Germany)
12. Libra Werk (W/Germany)
13. Klöckner Industrie Anlagen (W/Germany)
14. Comprimo (Holland)
15. Montedison (Italy)
16. Sturtevant (U.K.)
17. Mitsui & Co. Ltd. (Japan)

Eight firms answered that they could not make quotations due to several reasons as not covered by their activities, being to busy with other projects. In some cases the rejections were received after considerable interest was shown initially. Some firms that initially were willing to make a turn key job later communicated that they could only supply separate pieces of equipment. The construction of these parts into a production unit and its layout had to be done in the country. As no chemical engineering firm does exist in this country such a proposition cannot be accepted. For the reasons mentioned the firms 1, 3, 4, 10, 11, 12, 13, 14 dropped out.

Firms No. 5, 6, 15, 17 after having expressed their desire to offer quotations are very much in retard to do so.

End of April 20? FEEC, Wisconsin sent a proposal. Details were requested

Chartim Construction Cy, Como, Texas, USA, sent a useful preliminary solution satisfying all needs is to be realized soon. Chartim's bid was relatively low and their set up was according to demands.

Screening and Application Engineers, Sutton Coldfield, UK sent a proposal that deviated in many details from our setup. Discussions are underway, mainly as to the bulk handling and mixing units.

Nisho-Iwai, Tokyo, Japan, sen a preliminary proposal of a plant that apparantly has been built before in Japan. The plant contains too many items in stainless steel(even hoppers) and was almost entirely automatically controlled. Instead of a rotary mixer a gravitational type was proposed. Discussions are underway to arrive at a less sophisticated setup.

Voest, Linz, Austria sent a proposal not containing any details. A detailed proposal is requested.

Sturtevant Ltd. London UK sent a proposal for two plants of 20 tons capacity and were not willing to offer a plant for 40-50 tons/hour considering this capacity as not technically viable. Negotiations thereupon were terminated.

XII-2. As to automative equipment quotations were asked from several firms most of them having representations in Ethiopia. Tipping trucks of 6-7 tons capacity can be purchased from Mercedes, (W/Germany) and Maz (USSR). From other firms (Fiat) quotations are expected.

Wheelloaders of the desired quality can be purchased from Caterpillar (USA) and from Volvo BM (Sweden). The latter firm makes excellent equipment, but has no representative in Ethiopia. Fiat is expected to send quotations within short.

Grabs to be used with the ships' gear were offered by Nemag, Rotterdam (Holland) and are according to the company's needs.

Ventilation units containing fan, cyclone and bag filter were offered by Delta Neu, Lille, France. These units are very practicable ones and can be used near the spots where dust is generated. A wide range of units with capacities varying between 170 and 5,400 m^3/hour are available. Assembling is easily done using flexible ducts even in an existing installation.

A Truck weigher should be included in the final bid.

Laboratory equipment as well could be delivered by the final contractor as far as the more expensive items are considered. Regular supplies of glassware and chemicals should be obtained through local suppliers.

glassware and chemicals should be obtained through local suppliers.

XII-3. The final bids should contain the following items.

XII-3.1. Bulk handling equipment

XII-3.1.1. Hopper to receive raw materials transported by tipping trucks. This should preferably be an underground hopper fitted with a device to feed the subsequent bucket elevator. The top opening of the hopper has to be fitted with a coarse screen, with openings of about 5 cm square, a sliding valve should be fitted to the bottom.

Quantity: one

Hopper: capacity is 12 tons (max 18 ton); material: mild steel; screen: steel bars; sliding valve: mild steel Cap 150 t/hr as maximum peak load, normal load 120 t/hr.

Feeder : The feeder should either be a belt feeder or a vibrating feeder. A beltfeeder is easier to maintain. Material: mild steel. Drive: Electric motor closed type (P33 class Din in 40050 or similar) with appropriate gear box.

The hopper itself could be made in the country using the design made by the contractor.

XII-3.1.2. Bucket elevator

The bucket elevator has to convey the material from the hopper to a conveyor belt in the top of the storage builing. This belt is fitted in the trusses of the storage, that has a height of 15.5 m. The elevator should have ample height to feed the belt conveyor through a chute. The bucket elevator should be constructed outside the storage. Its feed end should be constructed in the underground construction mentioned in 3.1.1. Its discharge chute should enter the storage building at a convenient place.

Quantity: one

Capacity: 120 t/hr with peakloads of 150 t/hr

material: mild steel; chains should be hardened

Drive: Electric motor of closed type (class P.33- Din 40050 or similar). Gear box with chain drive at elevator head fitted with back stop.

XII-3.1.3. Horizontal belt conveyor system

A belt conveyor fitted with a discharge device should be constructed in the trusses of the roof.

The constractor should provide details of the conveyor frame, indicating how it should be connected to the trusses of the storage building. He should as well give indications as to the construction of the trusses. (The building, including the trusses shall be designed and constructed locally)

The discharge device should be either

a tipping off carriage or

a shuttle conveyor.

For convenience sake both could be motorized for easy shifting. Both systems can be used and there is basically no preference for one of them.

Quantity: one.

Capacity should be 250 t/hr with peak loads of 300 t/hr (the high capacity is needed as soon as the factory jetty becomes operational). Belt speed should not exceed 1.6 m/sec. Belt should be trough shaped.

Dimensions: length should be such that the 100 m at storage can be properly filled. The width of the belt should be about 900 mm.

Material: Structure: mild steel; Rollers with roller bearings. Belt: rubber with canvas or similar material.

Drives: Electric motors closed type (class P33-Din 40050 or similar) with appropriate gear boxes. Emergency switches should be provided for.

XII-3.2. Mixing Unit

The mixing unit having a capacity of 40-50 t/hr should contain a feeding hopper, a bucket elevator, a screen, a lump breaker, a four compartment hopper fed by a swivel spout and fitted with discharge valves, batch weigher, a mixer that should be of the rotary type and a discharge hopper. T.V.A. in many publications and from an experience of many years in a large number of plants recommends the setup mentioned above. This setup makes it possible to build a simple, compact and conveniently arranged plant. More specifically the rotary mixer that has small dimensions in vertical direction enables a good set up. On the contrary a gravity flow mixer has a considerable height (up to 10 m) and necessitates the use of a second bucket elevator, thus adding to high extra costs. Moreover the plant is badly surveyable and expensive automation is necessary.

XII-3.2.1 <u>Hopper</u> to receive raw materials conveyed by wheelloaders. The top should be wide enough to match the width of the wheelloader's bucket; 2.60 m will do.
The top should be fitted with a coarse screen with openings 5 cm square. The discharge end should be fitted with a sliding valve. The shape preferably should be an assymetric pyramid, if properly shaped a feeder device could be superfluous but in such a case the height of the hopper might increase.

The hopper could be constructed either with the top on groundlevel (or slightly above) or with the discharge and groundlevel. In the first case **filling** is easier and quicker, but an underground construction has to be made. In the latter case the top of the hopper should not be higher than 3 m in order to allow wheelloaders to discharge. A ground level hopper has definite advantages. If a feeder to the elevator (3.2.2.) is necessary this can either be a beltfeeder or a vibratory feeder. A belt feeder is easier in maintenance.

Quantity: one.

Hopper: Capacity 2.5-4 tons
material: mild steel
screen: steel bars
sliding valve: mild steel
feeder (if needed) capacity 80 tons/hr
drive: electric motor closed type
(P33 class-Din 40050 or similar)
and appropriate gear box.

The hopper could be manufactured locally.

XII-3.2.2. <u>Bucket elevator</u>

This elevator has to convey materials to the top of the building discharging onto a screen: The height of the elevator depends on the dimensions of the equipment to follow and should be determined by the contractor. The discharge should be closed and connected to the screen. A connection to a ventilation unit, should be provided for.

Quantity: one

Capacity: 80 t/hr

Material: mild steel; chains should be hardened.

Drive: electric motor of closed type (class P33-Din 40050 or similar) with appropriate gear box and chain drive at the elevator head. Fitted with back stop.

XII-3.2.3 Screen: to remove lumps

Vibrating screen either driven by an unbalanced motor or by electro magnetic vibrators.

Capacity: 80 t/hr

Dimensions depend on drive; 1.40 x 2.80 m might be a convenient size. Screen should be enclosed in a casing. Openings should be 5 x 5 mm. Discharge of on size material to swivel spout, discharge of oversize to lumpbreaker.

Quantity: one.

Material: frame mild steel

Screens: stainless steel wire

Drive. when unbalanced screen: electric motor closed type (class P33-Din 40050 or similar)

XII-3.2.4. Lump breaker

Its function is to break conglomerates of granules that are not very hard. Hammer mills and similar types are not suitable as they produce very fine product. Suitable equipment are flail mills and by preference cage mills.

Quantity: one.

Material: mild steel; cage mill bars hardened.

Capacity: maximum 5 tons per hour

Discharge: feed back to screen

Drive: Electric motor closed type (class P33-Din 40050 or similar)

XII-3.2.5 Four compartment hopper

Volume should be 8 m^3 per compartment or slightly more a swivel spout fed from the screen should feed the separate compartments. The swivel spout should be hand operated. Four valves (for instance of the sliding type) that can be operated at full discharge as well as at dribble discharge should be fitted to the hopper. These valves should be hand operated, however hydraulic or similar operation can be practical.

Quantity: one

Material: Hopper: mild steel.

Swivel spout: mild steel; spout section: stainless steel.

Valves, sliding part: stainless steel

The hopper could be made in the country using the design of the contractor.

XII-3.2.5[1] A communication system operated by the swivel spout operator should inform the payloader driver and the labourer at bucket-elevator 3.2.2 about the type of raw material to be conveyed. A light system with 4 lamps of different color is a good solution. This system can be buildt locally.

XII-3.2.6 Weigher

This is a batch weigher with a capacity of 2.5 to 3 tons. The valves of 3.2.5 should discharge into the bin of the weigher. A scale of ample dimensions, indicating kilograms should be conveniently placed to allow the operator easy control. A discharge valve at the bottom of large diameter should allow to empty the weigher in a very short time. This valve should be hand operated.

Quantity: one.

Material: mild steel, contact part of the bin stainless steel.

Discharge rough: well dimensioned open chute made out of mild steel.

XII-3.2.7 Mixer

The mixer should be a rotary one, constantly rotating in the same direction. Mixing and discharging to be effectuated without interruption of the rotation. Total of mixing plus discharge cycle has to be 3 min as a maximum. Discharge should be operated by bringing a special shaped chute in downward direction. The weigher operator operates the mixer as well. A small hold up remaining after discharge does not interfere with performances.

Quantity: one.

Material: mild steel rotating on steel or rubber tired wheels

Drive: Electric motor closed type (class P33-Din 40050 or similar) with appropriate gear box.

XII-3.2.8 Ventilation Unit

To deduct the discharge of elevator 3.2.2. and screen casing. A Delta neu unit could do the work.

XII-3.3. Bagging units

Two identical bagging units each of 40-50 ton/hr capacity are foreseen. Each unit contains: a feeder hopper, a bucket elevator, a double deck screen, a lumpbreaker, fines discharge, surge hopper to feed the weigher, a weigher (duplex), a bag filling spout, a heat sealer, a sewing machine and a slat or belt conveyor. Both units should be built in one steel construction together with the mixing unit. A shaft to hoist equipment for erection and for maintenance purposes preferably should be provided for.

The units should be used either to bag straight or mixed fertilizers. One of them should mainly be used for mixed fertilizer, the other one for straight fertilizers.

XII-3.3.1. Hopper The hopper of at least one unit should be located in such a way that the mixing plant can discharge directly into it. The hopper of the second unit should be situated in such a way that in case of break down this unit can be used as well to bag mixed fertilizers. An auxillary movable belt conveyor could perform this task.

Hoppers have to be fitted with devices to feed the bucket elevators. Belt feeders are convenient. Dimensions of the hopper as 3.2.1. Hoppers should be fitted with a bar screen.

Quantity: two

Material: as 3.2.1.

Drive: as 3.2.1

XII-3.3.2. Bucket elevators to convey material to the double deck screen. The height depends on the dimensions of the equipment used in the bagging plant. It should be determined by the contractor. The discharge should be closed and connected to the screen; a spout to connect with a ventilation unit should be provided for.

The capacity should be 80 t/hr. Dimension of buckets, chains, drive wheels, drives should be the same as for elevator 3.2.2. Spare parts can then be used for each of the three elevators. In fact the capacity is rather high but for simplicity sake it should be advised to have three elevators of the same type.

Quantity: two

Material: as 3.2.2.

Drive: as 3.2.2.

XII-3.3.3. Double deck screens to remove lumps and dust having a capacity of about 60 t/hr. Dimensions depend on type of drive etc; 2.20 x 2.50 might be a convenient size in case of an unbalanced driven type. When used with mixed fertilizers (freshly prepared) no lumps are present and the upper wire screen can be **removed**. In this case only the dust screen (0.6 x 0.6 mm) is used. When the purchased raw materials meet all specifications (see IX-1) and contain no material caught on screen Tyler 28 or 0.59 mm the screening operation is superfluous. However in most cases transportation and handling are the cause of formation of dust particles by abrasion. Dust separated should be conveyed through a vertical pipe (steel or p.e.) to a receptical on floor level.

Oversize should be conveyed to the lumpbreaker.

Quantity: two

Material: frames: mild steel

screens: stainless steel wire

Drive: In case of unbalanced type electric motor (class P33-Din 40050 or similar)

XII-3.3.4. Lump breaker

Exactly as 3.2.4

Quantity: two

XII-3.3.5. Surge hopper to weigher

Dimensions will depend on those of weighers and whether duplex or single weighers are to be installed. Most types have sliding plates to be placed in a prefixed position in order to have a convenient flow to the weighing machine. Weighers and surge hoppers should be constructed as matching units.

Quantity: two

Material: mild steel, outlets eventually out of stainless steel.

XII-3.3.6. Weighers

Capacity has to be 40-50 tons or 800 to 1000 unit loads of 50 kg per hour. Weighers have to be of the "net weigher" type. The best choice generally is a duplex weigher were alternatively one weigher is filled to a 50 kg load and the other one is discharged into a funnel to which a bagging spout is fixed. Discharge of the weigher is operated by the operator of the bagging spout. In most cases operation is pneumatically or electrically assisted.

Quantity: two

Material: preferably stainless for weighing bucket and discharge valves. For the rest as offered by renown manufactturers.

However the experience of the manufacturer should settle the problems. Therefore a well known make is very important.

XII-3.3.7. The filling spout with discharge funnel should be fitted to hold 50 kg bags. Annex XIII-B gives a description of a suitable type of filling spout. As the (inner) bag has to be heatsealed the inner side of it has to be free of deposits of dusts.

Quantity: two

Material: mild steel

discharge funnel: preferably stainless steel

XII-3.3.8. Heat sealers

Should be able to seal polyethylene bags having foil thickness of 0.05 -4 mm. The sealing is performed by two belts made out of stainless steel or other suitable material, both belts having the same speed. The belts are heated electrically and welding taken place by pressing rollers. After welding the welds are cooled. Heating should be thermostatically controlled. Belt speed should be adjustable. The welding equipment should be adjustable to different bag lengths. An additional bag cleaning unit might be practical.

Quantity: two

Materials: as offered by renown manufacturers.

XII-3.3.9. Sewing machines

This item should be able to sew woven jute, poly propylene and similar bags. The height of the sewing head should be adjustable to different bag lengths.

Quantity: two

Material: as offered by renown manufacturers.

XII-3.3.10. Conveyor

A slat or belt conveyor has to convey filled bags to the welding and sewing machine. Its speed should be easily adjustable to meet the performances of both machines. Guide boards have to prevent bags from tumbling.

Quantity: two

Material: mild steel

if belt conveyor: a rubber or similar belt if slat conveyor: wooden slats on chains

Drive: electric motor closed type (class P33-Din 40050 or similar)

XII-3.3.11. Air compressor

An air compressor is needed when bag clamps and other equipment are operated pneumatically. Capacity should allow to operate both units. A unit able to produce about $30m^3$ per hour at 4-6 atm will be satisfactory in most cases.

Quantity: one

Drive: Electrical motor closed type (class P33-Din 40050 or similar)

XII-3.3.12. Ventilation

The discharge of the bucket elevators and of the filling spouts should be ventilated as relatively much dust is developed at these spots. The discharge chutes of the bucket elevators can either be ventilated by one unit or by two separate ones. In case one unit is used care should be taken that piping does not contain narrow bends and large horizontal ducts. Two separate units are easier to operate. Capacity should be about 1000 m^3/m at 60 mm w.g. per unit. The filling spouts preferably should be ventilated by a separate small unit; its capacity should be 45-60 m^3 per hour per filling spout. Air velocity measured on the spout where dust possibly could settle should be 75-100 cm per second.

It should be considered to use for these purposes small units that contain fan, cyclone and dust filter and that can be easily handled.

XII-3.3.13. Some additional equipment as a table near the bag filling operator to hold a stock of empty bags, wooden devices to combine inner and outer bags can be made locally.

XII-4. Harbour equipment

Separate bids should be asked for these items. Necessary are grabs and hoppers.

XII-4.1. Grabs should have a capacity of $2m^3$. As they have to be used with the ships equipment they should be of the "one rope" type. Grab manufacturing is highly specialized and only few firms do construct reliable equipment. Among them are Nemag, Rotterdam, Holland and Demag, W/Germany

Quantity: three

Material: mild steel.

XII-4.2. Hoppers

Hoppers should have a wide enough opening to be loaded with grabs and be heigh enough to enable trucks to be loaded. A suitable type was used at Assab-Harbour by Ethiopia Amalgamated. This hoppers can be made locally.

Quantity: three.

Material: mild steel

XII -5 Automotive equipment Tipping trucks to convey raw materials from the harbour to the factory are needed as well as wheel loaders for transportation within the factory. Possibly a wheelloader or a loader on tracks or a similar machine will be necessary at the filler quarry. Unless more details are known about this quarry it is not possible to specify the needs

XII-5.1. Tipping trucks with capacities of $7m^3$ or 6 tons are considered to meet the needs. Several firms do import these items(FIAT, Ethso, Mercedes etc.)

Quantity: eight.

XII-5.2. Wheelloaders

Capacity should be 1.2-1.4 ton per load. Bucket width should not exceed 2.4 r. Imported are Caterpillar, FIAT-Allis. Very good loaders at reasonable prices are made by VOLVO., Sweden but as apparently they do not have a representative in Ethiopia there might be maintenance problems.

Quantity: two.

XII-6. Material for handling bagged fertilizer. They include belt conveyors and movable belt conveyors for piling purposes.

XII-6.1 Wheel barrows that can carry 4 bags on top of each other are foreseen for transportation of filled bags to and from storage and for transportation to trucks. They can be purchased locally.

Quantity: forty.

XII-6.2 Piling equipment

Either a belt or a slat conveyor that can be easily adjusted to different heights of piles is needed. Maximum height of piles is 5-6 m.

Quantity: two.

Either rubber belts with special profile or wooden slats are required.

Drive: electric motor closed type (class P33-Din 40050 or similar) with suitable gear box.

XII-7. Laboratory equipment

In Chapter VII-6-4 equipment needed is mentioned in detail. Apparently no traders in the country are dealing with these items. The most convenient way to purchase these items are through the intermediate of the main contractor. However, this will not be the cheapest way. **Contacts** with university laboratories and similar institutes might result in joint activities. Costs will then be lower.

XII-8. Truck weigher. Should be able to weigh trucks and trailers up to 22 tons loads. Preferably this item should be an electronic type. using special measuring elements.

XII-9. Buildings

The following buildings are needed.

Raw material storage.

Bagged fertilizers storage

Office building

Building for mixing and bagging units.

XII.9.1. Raw Material storage

In chapter VII-Annex 1. this building is described in details. Type B-II is the best solution.

This building contains trusses that have to be shaped in such a way that the belt conveyor mentioned in XII-3.1.3 can be assembled in these trusses. Details should be given by the contractor dealing with the belt conveyor.

The building contains L-shaped concrete wall sections.

The design and construction of the building should be carried out by local contractors.

XII-9.2. Bagged fertilizer storage

This building is described in Chapter VII- Annex 5.

It can be designed and contructed by local contractors.

XII-9.3 Office Building

This office is dealt with in a general way. A detailed layout should be made by a local designer. Construction should also be made by a local contractor.

XII-9.4. Building for mixing and bagging units

Essentially this building is a steel structure designed to contain the equipment. Therefore the contractor dealing with the equipment items should design the steel structure. The structure preferably should be made in the country, using drawings purchased by the contractor. It should be fitted with sidings and roofing made out of corrugated asbestos cement.

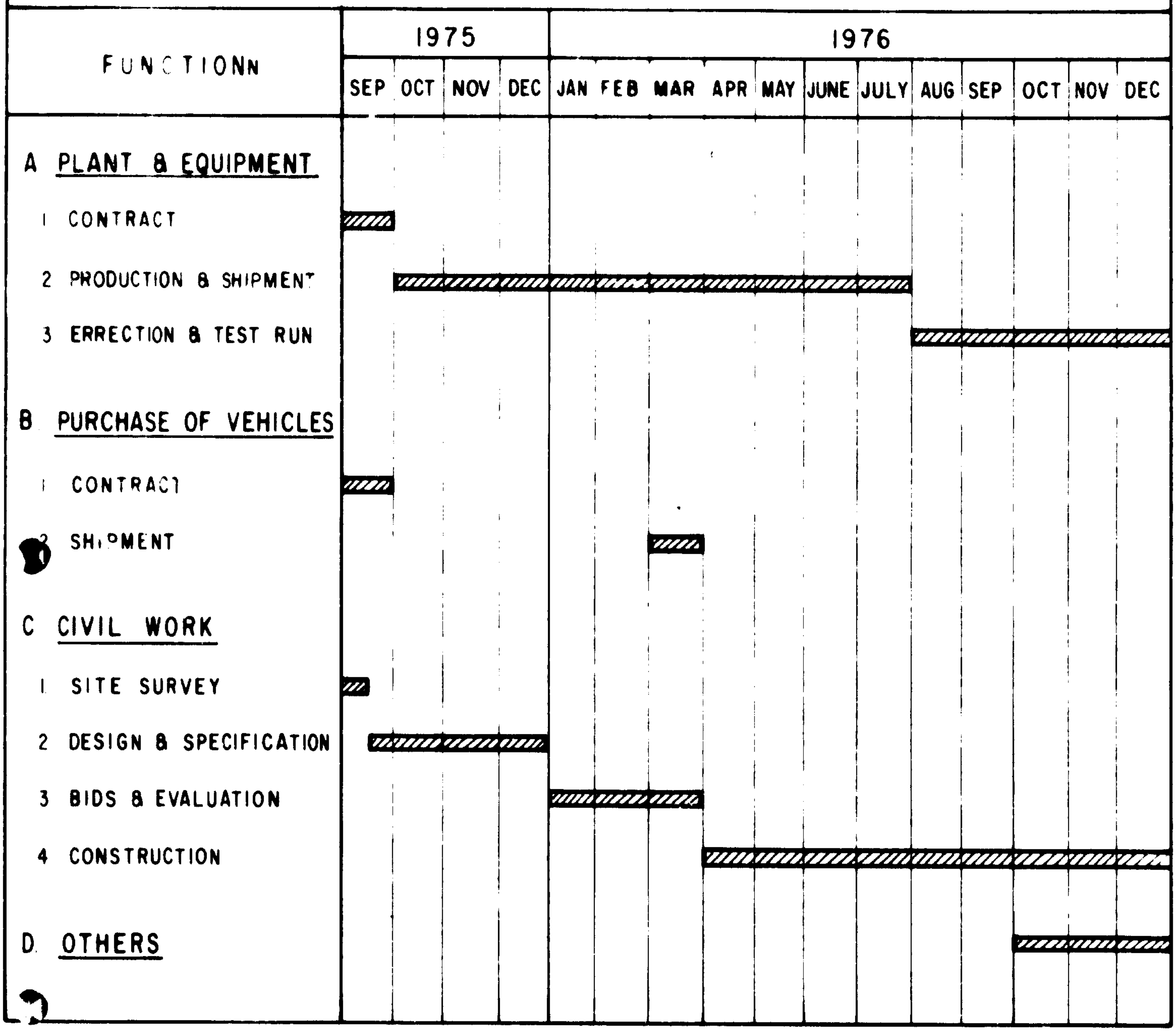
XII-9.5. Roads and fencing should be designed as soon as details about the site are available. Construction is to be done by local contractors.

XII-10. Miscellaneous

Bidding documents should be drawn up in a clear way to avoid misunderstandings and ambiguous interpretations.

The "Guidelines for procurement...." used by the I.B.R.D. contain valuable information for bidding documents.

IMPLEMENTATION SCHEDULE
FERTILIZER HANDLING, BLENDING AND BAGGING PLANT



Annex A

Terms of Reference

Project ETH/73/009

Establishment of a Fertilizer Bulk Handling, Mixing and Bagging Plant.

1. Mixing and Bagging Plant:

1.1.

1.1.1. Determine capacity of the mixing and bagging plant including storage required based on the information as regards demand to be provided by the AID Bank.

1.1.2 Determine type and size of storage and production buildings.

1.1.3 Determine type and quantity of equipment needed for storage, mixing, bagging and internal transport.

1.1.4 Determine capital costs of the above items.

1.1.5 Recommend alternative technologies keeping in mind the use of labour intensive methods.

1.1.6 Make the recommendations in such a way that expansion of the plant at a later stage to meet larger output either from imported from locally purchased fertilizers be possible.

1.2 Specify the type of bags required for the operation and compare the alternative of importing them with the alternative of manufacturing them domestically.

2. Port Site Study:

2.1 Evaluate the available utilities.

2.2 Study port storage facilities (temporary).

2.3 Study unloading and transport facilities presently existing at the port.

2.4 Study seasonal fluctuations in ship arrivals.

2.5 Study future plans for port expansion

2.6 Select a suitable site for the mixing plant, with due consideration to distance from public utilities, highways, as well as size of the plant, and possibility of using the same site for a complete manufacturing complex some time in the future.

2.7. Study the possibility of having another independent berth.

2.8 Study the alternative of locating the plant inland.

/...

3. Unloading and Transport Facilities:

3.1 Study the policies of the Port Authority with respect to unloading and transport facilities.

3.2 Study the various methods of unloading and transport fertilizers in bulk, as outlined below, in the light of financial implications as well as operating and maintenance requirements.

3.2.1 Unloading by ship's own derrick crane and transport by trucks equipped with appropriate containers.

3.2.2 Unloading by suction pump and transportation through pipes or open conveyor belt.

3.2.4 A combination of bucket conveyor and piping system.

3.2.5 Other Methods.

3.3 Study the possibility of using the salt works' facilities.

+4. Inland Transport and Storage Facilities:

4.1 Assess the logistics and difficulties of transporting fertilizer from the port into the interior, with special emphasis on availablity of trucks and freight charges.

4.2 Assess existing inland storage facilities for fertilizers.

4.3 Undertake a systems study to determine (in relation to proposed facility capacities at port and plant site) the optimum truck fleet for transporting bagged fertilizers inland and also additional inland storage facilities.

5. Utility Requirements:

5.1 Estimate electricity, fuel, water, etc. requirements, consumption per unit of output, and cost.

6. Manpower and Training Requirements

6.1 Estimate requirements for each capacity level considered and give breakdown into skilled, unskilled, technical, managerial, national and foreign (if any).

6.2 Estimate training requirements and costs, and work out a training programe.

63. Recommend appropriate ways of acquiring know-how and/or technical skills, if this is considered necessary.

/...

+7. Workers' Residence:

7.1 Compare the desirability of building employees' residence at the plant site with the alternative of providing them with transport services and suggest whichever is more economical.

+8. Specifications:

8.1 Prepare detailed specifications for all equipment and facilities (Including all storage facilities and "internal" transport systems among different parts of the plant) proposed and indicate the "equipment/plant performance" guarantee to be required.

8.2 Prepare detailed invitations to tender.

8.3 Suggest a list of possible prospective bidders.

+9. Drawings:

9.1 Prepare preliminary drawing indicating proposed arrangement of equipment and machinery, facilities, building, showing the tie-in with transportation and materials handling equipment.

+10. Implementation Schedule:

10.1 Estimate carefully implementation schedules, showing the flow of project work up to entry into operation of the project.

10.2 Prepare a commissioning procedure specifying the trial tests to be carried out upon completion of the project to ascertain, before final acceptance, that the plant will perform according to specifications.

+11. Fixed Investment Cost Estimates:

+11.1 Cost of land and land improvements.

+11.2 Cost of access road

+11.3 Cost of buildings, broken down into factory, storage and office buildings.

+11.4 Cost of machinery and equipment, broken down into CIF, port clearing charges, bank charges, handling and cost of transporting to site.

+11.5 Engineering and installation costs broken down into foreign exchange and domestic currency components.

+11.6 Cost of trucks detailed as in (11.3) above.

/...

+11.7 Cost of office equipment and furniture.

11.8 Pre-operation expenses: wages and salaries, other administration costs, training costs, company formation expenses, consultants' fees, interest during construction period (if any) start-up costs, etc. Show each separately and broken down into domestic and foreign currency.

11.9 Replacement investments by type of asset and by year.

11.10 Provision for possible cost over-runs (due to possible quantity and price increase.

+12 Operating costs:

+12.1 Variable Costs	Domestic Currency	Foreign Currency
12.1.1 Materials		
12.1.2 Bags		
12.1.3 Production labour		
12.1.4 Electricity		
12.1.5 Fuel		
12.1.6 Water		
12.1.7 Steam		
12.1.8 Repair and maintenance:		
Plant		
Transportation system (from ship to plant)		
Trucks		
12.1.9 Transport		
12.1.10 Others		

12.2 Fixed and Semi-Fixed Costs:

12.2.1 Supervision personnel
12.2.2 Management personnel
12.2.3 Interest (if any)
12.2.4 Insurance
12.2.5 Rent (if any)
12.2.6 Selling expenses
12.2.7 Telephone, etc.
12.2.8 Legal and audit fees
12.2.9 Depreciation and amortisation@
12.2.10 Others

@ Give detailed, separate schedules.

+ Assistance from the economic department or the legal department or the engineering department of the AID Bank is required.

13. Working Capital Requirements:

13.1 Stocks:

13.1.1 Unbagged fertilizers

13.1.2 Bagged fertilizers

13.1.3 Bags

13.1.4 Spare parts

13.1.5 Other stocks

13.2 Receivables (credit sales), if any.

13.3 Prepaids (insurance, utility deposits, etc.)

13.4 Minimum cash balance.

Addis Ababa,
19 September, 1974

Annex - B

B-1

Sealing of open mouth plastic bags

1. Sealed plastic bags offer many advantages; they are relatively cheap and a water and airtight closure is easily obtained. Particularly if products are hygroscopic and are to be used in wet climates sealed bags are preferable to all other types of bags. Sealed bags are either used as such in which case foils of about 0.2-0.4 m should be used or are used as liners in woven bags (jute, kenaff, polypropylene), then a foil thickness of 0.05-0.1 mm preferably is used.

   Polyethylene is the best material for a plastic bag; p.v.c. has a 10 times higher permeability for water vapour and tends to be brittle at temperatures below 4°C.

2. Air tightness of sealed plastic bags is that perfect that it is necessary to make some holes in the bags in order to allow excess air to escape. These holes have to be punched near the upper end of the bags; their diameter have to be 0.2 to 0.3 mm. Care should be taken that the ventholes are not made by pricking holes with a needle. In that case tearing of the plastic foil might occur. If excess air cannot escape, expansion of air by heat blows up the bag and prevents stable piling of bags and consequently piles may collapse.

3. The most important condition to make perfect seals is that the surfaces to be sealed are perfectly clean and free of disposal of dust. The bag as it leaves the factory is very clean. Only during filling operations it can be contaminated with dust. Two measures to prevent contamination have to be taken.

   (a) The product to be bagged has to contain only very small quantities of dust.

   (b) The filling spout must be constructed in such a way that dust disposal on the inner side of the bag is prevented. The second condition is the most important one.

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I made (1973) a study on fertilizer production problems at Maroc Chimie Factory in Morocco. Maroc Chemie had planned to bag fertilizers (D.A.P and others) in open mouth p.e. bags to be heat-sealed.

Equipment contained a Libra heat-sealing machine (W.German make) and a simple filling spout. No dust was removed from the product to be bagged by screening. Maroc Chimie never succeeded to produce properly sealed bags and finally they abondoned the project.

Now from experiences during many years I know that the Libra sealer is an excellent piece of equipment providing clean dust-free surfaces are present. If so there is no problem to produce continuously millions of bags without failures.

As to (a) it can be said that most manufacturers of fertilizers deliver products with a very low percentage of dust and when ordering fertilizers it should be specified that no product passing a sieve of 28 Tyler or 0.59 mm is present. But it must be kept in mind that during transport and unloading activities abrasion takes place and dust is formed. Therefore it is of great importance to remove the small quantities of dust before feeding the material to the weighers. This has to be done using a screen with a gauze of 10 x 1.8 mm. The fines amount as a maximum 1%; but in the majority of cases it will be far less. These fines present-apart from its granulometric properties-excellent fertilizer material. They should be sold at a reduced price.

As to (b) a special spout has to be used, there do exist several types of filling spouts that are constructed is such a way that dust cannot be deposed on the inner surface of the plastic bag.

One of the good filling spouts is that of Haver and Bocker (Oelde. W. Germany). Such a filling spout has been offered to AID Bank by H & B on 16th October 1974. The machinery contains two jaws shaped in the form of a bird's bill. These jaws have a width of 320 mm. After placing the bag the jaws are opened and the bags are pressed against rubber-clad bars. So the part of the bag between jaw and bar is protected from dust disposal.

/...

The filling spout itself is a cylindrical tube surrounded by a concentrical tube that is connected to a ventilation circuit. The air passes the unprotected area of the bag in downstream direction and escapes in the concentrical ring, taking away possible dust particles and thus preventing them to settle on the plastic bag. Air velocity has to be 75-100 cm per second on the spots where possibly dust could settle. A fan with a capacity of 45-60 m^3/hr will do; a cyclone and a dust bag complete the ventilation unit. Very compact ventilation units are built by Etablissements Neu, Lille, France (Delta Neu ventilation units).

Fig 1 gives a sketch of the H & B filling spout.

4. As to the heatsealer (of Libra) there are some details to be mentioned. In this type of sealer the sealing procedure is based on contact heat by pressing heated glass fibre or stainless steel belts towards the top of the plastic bag to be closed. The belts are made of 50 mesh (0.29 mm) woven gauze; stainless steel wire or 0.2 mm thickness being used to wave the belt. The belts are coated with teflon. These contact sealers can be used for a wide variety of foil thickness. There do exist several types of reliable heat sealers based on the same principle (as the Doboy sealer and others). Sealers based on radiant heat are offered; apparently they cannot be used with foils having a thickness of 0.05-0.1 mm which is the thickness of the usual liner bag.

5. To ensure that sealing is done properly bags should be submitted to a falling test. Test D959-48T.A.S.T.M. dictates six successive free falls from a height of 1.50 m. After each fall contents in the bag should be arranged evenly. The bags should not be ruptured in this test. See: I.S.M.A. 3rd technical and agronomical meeting, Stresa 1969. Paper XXI PSF/67, Versteegh and Van Den Brink.

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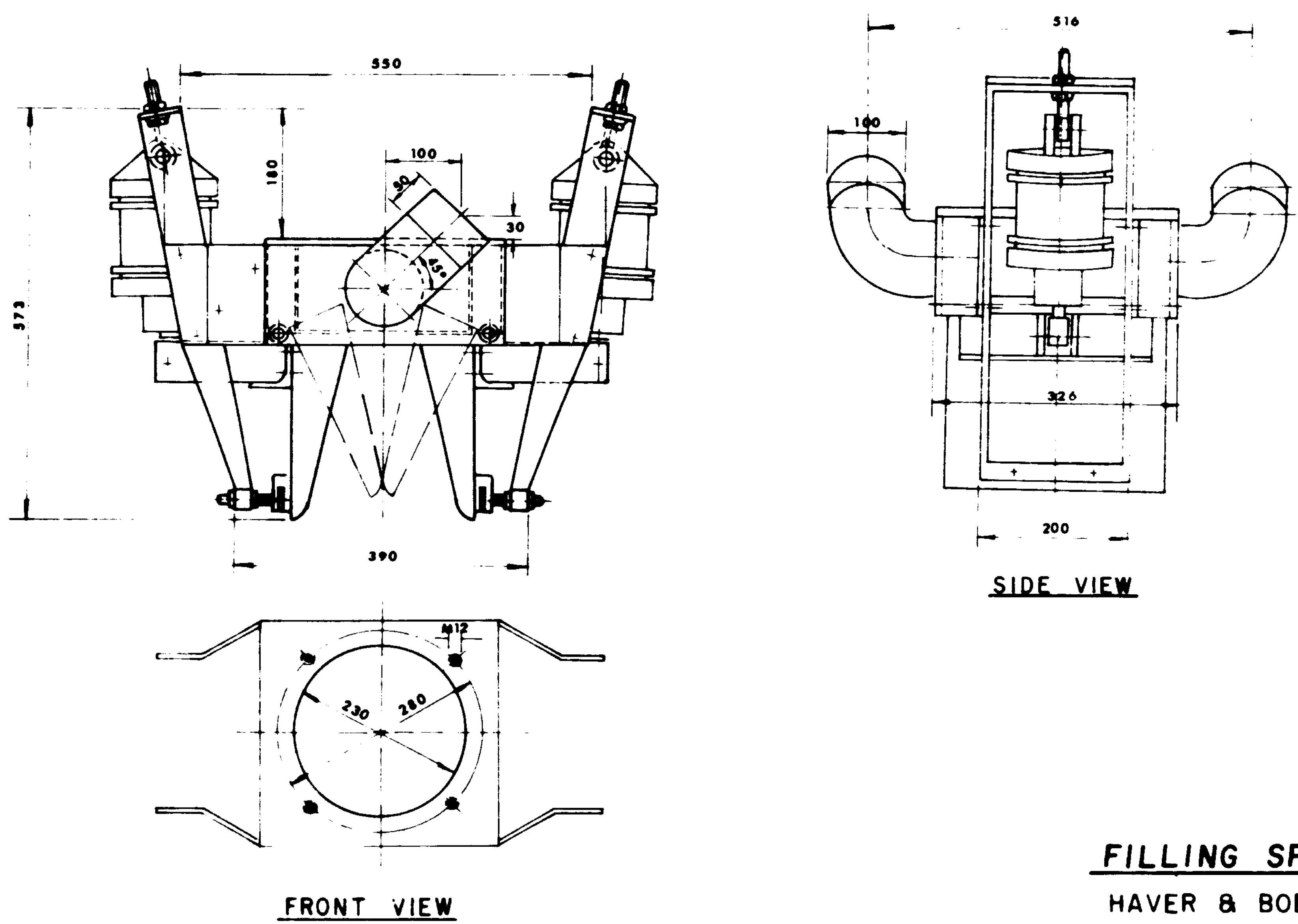

FILLING SPOUT

HAVER & BOECKER
OELDE (WESTFALEN)
WEST GERMANY

SCALE 1 50

Ann B Fig-1

6. Bags made out of p.e. foil of 0.2-0.4 mm thickness are widely used in W/Europe. These bags have no woven outer bags. They are reliable and withstand heavy conditions as transport per seagoing ships, trucks and intermediate storage. No hooks should be used on these bags, however the same applies to woven bags with p.e. liners. The above mentioned single p.e. bags should be considered seriously after a thorough investigation of handling conditions between factory and farmer. Single p.e. bags are considerably cheaper as compared with combinations of woven bags and liners.

7. This is essentially a version of a report made in 1973 on behalf of the Moroccan Government for the Fertilizers Work "Maroc Chimie" in Safi (Morocco) (UNIDO T.C.D. 249; Rapport No. 7) November 1973.

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ANNEX - C

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	Ato Tesfaye Dinka, Ministry of National Development
	Ato Wondwossen Sahl, Civil Engineer, counterpart
	Dr. Asrat Teferi, Head of Research Dept.
	Ato Tadewos Harege Work, Electrical and Cement Engineer
	Dr. E. Geoffry Gowen, UN Economist
	Ato Lemma Merid, Economic Assistant
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ANNEX - D.

References

"Fertilizer Manual" UNIDO 1969

"Technical and Economic Feasibility of Bulk Handling-Blending in Guatamala"
Tennessee Valley Authority U.S.A. 1974

T.P. Hignett " Bulk Blending"
Proceedings No.87. The Fertilizer Society,
London U.K. 1964.

"Modern Methods in the Handling of Fertilizer"
Proceedings No.82. The Fertilizer Society,
London U.K. 1964

J.S. Garr... "Prefeasibility Study Fertilizer Manufacture in Ethiopia", U.N.I.D.O 1972

M.E. Gertsch "Fertilizer Demand in Ethiopia",
U. N. I. D. O, 1972
K.A. Sherwin. "Fertilizer Procurement and Distribution", U. N. I. D. O, 1972

D.L. Rucker "Fertilizer Marketing and Credit Problemsin Ethiopia" Interim Report, FAO, Rome 1974

T.P. Hignett, "New and Improved Fertilizer material based on Urea" 2nd Interregional Fertilizer Symposium, Kiev/New Delhi UNIDO, Vienna, 1971

"Recent Developments in the Fertilizer Industry"
UNIDO, Vienna 1972

"Directory Fertilizer Production Facilities"
Part 1 Africa, UNIDO, 1970

"Fertilizer Requirements of Developing Countries"
I. B. R. D. 1974

Hanmo Bahta, "The Fertilizer Industry in Ethiopia"
2nd Interregional Fertilizer Symposium Kiev/New Delhi,
UNIDO 1971

"The Demography of Ethiopia, Statistical Bulletin 10"
Central Statistical Office, Addis Ababa, 1974

W. J. Abraham "Staff Report No. 3"
Central Statistical Office, Addis Ababa, 1972

"Annual External Trade Statistic 1967 - 1973"
Customs Head Office, Addis Ababa, 1974

G. Andreason "<u>Insecticides</u>"

Survey of Consumption and Production of Insecticides
in Ethiopia, UNIDO, 1974

Sauchelli "The Chemistry and Technology of Fertilizers",
New York, 1960

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